



## Comparison of pulse oximeter, cold test, and electric pulp test for assessment of pulp vitality in permanent immature teeth

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### Abstract

**Background:** To compare pulse oximeter, cold test, and electric pulp test for assessment of pulp vitality in immature permanent teeth.

**Materials & methods:** A total of 50 teeth were enrolled. This cross-sectional study included permanent maxillary incisors in based on the degree of root development (complete or incomplete). The results were analysed using SPSS software.

**Results:** Cold test and EPT diagnosed all endodontically treated teeth as non-vital (true positive). Pulse oximeter had the highest diagnostic accuracy with 96% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter was 100% and 97.5%, respectively.

**Conclusion:** Pulse oximetry has a higher specificity and better accuracy than the cold test and the electric pulp test in assessing the pulp vitality in the diagnosis of vital teeth.

**Keywords:** Electric pulp test, Cold test, Pulp Vitality.

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## **Introduction**

In endodontics, dental pulp testing is a significant and essential diagnostic aid since diagnosis is an integral aspect of treatment planning.<sup>1</sup> The gold standard of determining vitality status of pulp is directly inspecting it by histological section examination. However, as the pulp is enclosed by a calcified barrier, this cannot be carried out before starting endodontic therapy.<sup>2</sup> Pulp vitality normally represents the integrity of vascular supply to the tooth. Pulp dentin complex is also richly innervated by sensory fibers, predominantly A-delta and C fibers.<sup>3,4</sup> Most of the vitality tests in everyday practice such as thermal tests and electric tests are dependent on the stimulation of these nerve fibers. It is more reliable to name them as pulp sensitivity tests rather than pulp vitality tests as they fail to assess the blood supply to the tooth. Limitations of these routine vitality tests include they are subjective responses and clinical symptoms and radiographs over the time is the only method to objectively determine the pulpal status. They also give false positive and false negative response for example in traumatized teeth, necrotic teeth, patients with psychotic disorders and under the influence of drugs or alcohol. They give no information on the degree of inflammation of the pulp and its state of vascularity.<sup>5</sup>

In children, immature permanent teeth have not been completely innervated by the alpha myelinated axons which are responsible for the pulpal pain response. Nerves are more resistant to inflammation and may give a false positive response to stimuli even after degeneration of pulp tissue.<sup>6,7</sup> On the other hand, it is important that clinicians use a more accurate and highly specific test for detecting a vital tooth in order to prevent improper dental treatment. There are other modalities for assessment of blood circulation of dental pulp including the laser Doppler flowmeter, pulse oximetry, spectrophotometry, and photo plethysmography.<sup>8</sup> Sensitivity and specificity best define the validity of a diagnostic test, while its clinical usefulness in a given population is best described by its positive and negative predictive values (PPVs and NPVs).<sup>9</sup> Sensitivity is the proportion of cases identified correctly using the diagnostic test whereas specificity is the proportion of noncases identified correctly using the diagnostic test. Meanwhile, the positive predictive value is the proportion of positive test results that are cases and negative predictive value is the proportion of negative test results that are noncases.<sup>10</sup> Hence, this study was conducted to compare pulse oximeter, cold test, and electric pulp test for assessment of pulp vitality in immature permanent teeth.

## **Materials & methods**

A total of 50 teeth were enrolled. This cross-sectional study included permanent maxillary incisors in based on the degree of root development (complete or incomplete). Pulp vitality was assessed by an expert clinician using pulse oximeter, cold test, and electric pulp test. Based on the true and false positive and negative responses, the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated. The results were analysed using SPSS software.

## **Results**

Pulse oximeter test correctly diagnosed all 50 vital teeth as vital (true negative). The cold test diagnosed 40 teeth as vital (true negative) and 10 as non-vital (false positive). In endodontically treated teeth, pulse oximeter diagnosed 17 teeth as non-vital (true positive) and one tooth as vital (false negative). Cold test and EPT diagnosed all endodontically treated teeth as non-vital (true

positive). Pulse oximeter had the highest diagnostic accuracy with 96% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter was 100% and 97.5%, respectively.

Table 1: Comparison of diagnostic parameters in permanent central incisors with three-fourth of the root length formed

Parameter	Pulse oximeter	EPT	Cold test
Sensitivity	96%	100%	100%
Specificity	100%	66%	75%
Positive predictive value	100%	50.5%	65%
Negative predictive value	97.5%	100%	100%
Diagnostic accuracy	97.8%	70.2%	80%

Cold test and EPT detected all endodontically treated teeth to be non-vital (true positive). Pulse oximeter had the highest diagnostic accuracy with 96% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter were 100% and 97.5%, respectively.

Table 2: Comparison of diagnostic parameters in permanent central incisors with complete root length formed

Parameter	Pulse oximeter	EPT	Cold test
Sensitivity	96%	100%	100%
Specificity	100%	85%	85%
Positive predictive value	100%	70.5%	70.5%
Negative predictive value	97.5%	100%	100%
Diagnostic accuracy	97.8%	90%	90%

## Discussion

Many of the studies in the literature have focused on efficacy of pulse oximetry in measuring the oxygen saturation levels of teeth in different conditions like traumatic cases, vital, non vital and teeth with open apices. 11,12 It had been proven that pulse oximetry is a significant and prompt true vitality testing device compared to conventional vitality tests. Setzer FC et al., conducted a study assessing pulp oxygen saturation levels in only posterior teeth with different pulpal inflammations which prompted us to study the effectiveness of pulse oximetry on anterior teeth with different pulpal conditions. 13 Hence, this study was conducted to compare pulse oximeter, cold test, and electric pulp test for assessment of pulp vitality in immature permanent teeth.

In the present study, pulse oximeter test correctly diagnosed all 50 vital teeth as vital (true negative). The cold test diagnosed 40 teeth as vital (true negative) and 10 as non-vital (false positive). In endodontically treated teeth, pulse oximeter diagnosed 17 teeth as non-vital (true positive) and one tooth as vital (false negative). Cold test and EPT diagnosed all endodontically treated teeth as non-

vital (true positive). Pulse oximeter had the highest diagnostic accuracy with 96% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter was 100% and 97.5%, respectively. A study by Anusha B et al, the mean oxygen saturation levels of RP, IP, PN, PC and NC were 85.4%, 81.6%, 70.7%, 94.6% and 0 respectively. There was significant difference in the oxygen saturation levels between all the groups. Pulse oximeter is an effective tool in diagnosing different pulpal pathologies especially PN which was interpreted inaccurately by thermal tests.<sup>14</sup>

In the present study, cold test and EPT detected all endodontically treated teeth to be non-vital (true positive). Pulse oximeter had the highest diagnostic accuracy with 96% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter were 100% and 97.5%, respectively. Another study by Molaasadolah F et al, the pulse oximeter showed diagnostic accuracy of 98.7% in the permanent central incisors with complete and incomplete roots and 100% in the permanent lateral incisors with complete and incomplete roots. The diagnostic accuracy of the electric pulp test was 76.2% and 92.5% in the incomplete and complete central incisors, respectively, and 76.2% and 83.7% in the incomplete and complete lateral incisors, respectively. The cold test had a diagnostic accuracy of 85% and 92.5% in the incomplete and complete central incisors, respectively, and 91.2% and 88.7% in the incomplete and complete lateral incisors, respectively.<sup>15</sup> The sequence of pulp sensibility tests varied among individual studies. The application of EPT followed by thermal testing is a common sequence of pulp testing.<sup>16</sup> However, according to Pantera et al.,<sup>17</sup> the sequence of pulp tests had no effect on the results of the tests when EPT and ethyl chloride were reversely used. Among the majority of included studies accessing accuracy of PO, custom-made specific dental probes were used which allows the maintenance of a constant path length for the light emitted from the LED and received by the photoreceptor sensor, thus enabling accurate readings.<sup>18,19</sup> To obtain the oxygen saturation of the tooth, Sharma et al.<sup>20</sup> employed an ear probe, whereas Samuel et al.<sup>21</sup> used a customized ear probe based on the anatomical shape of permanent incisors. Janani et al.<sup>22</sup> studied 79 single canal teeth that required endodontic treatment; they compared the pulp, electrical, and pulse oximeter heat tests followed by endodontic treatment. Then, clinical trials were compared with clinical findings after cavity preparation. It was concluded that the greatest similarity and correlation were found between the pulse oximeter test result and the clinical findings.<sup>23</sup> Sensitivity value was similar to study by Gopikrishna V et al., which was equal to 1 whereas specificity value was higher when compared to Gopikrishna V et al., which was 0.95 because author selected teeth with irreversible pulpal changes.<sup>24</sup>

## **Conclusion**

Pulse oximetry has a higher specificity and better accuracy than the cold test and the electric pulp test in assessing the pulp vitality in the diagnosis of vital teeth

## **References**

1. Chen E., Abbott P. Dental Pulp Testing: A Review. *Int. J. Dent.* 2009;2009:365785.
2. Weisleder R., Yamauchi S., Caplan D., Trope M., Teixeira F. The Validity of Pulp Testing. *J. Am. Dent. Assoc.* 2009;140:1013–1017.
3. Abd-Elmeguid A, Yu DC. Dental pulp neurophysiology: part 1. Clinical and diagnostic implications. *J Can Dent Assoc.* 2009;75(1):55–59.
4. Oloart L. Excitation of intradental sensory units by pharmacological agents. *Acta Physiologica.* 1974;92(1):48–55.
5. Arun A, Mythri H, Chachapan D. Pulp vitality tests - an overview on comparison of sensitivity and vitality. *Indian J Oral Sci.* 2015;6:41–46.

6. Karayilmaz H, Kirzioğlu Z. Comparison of the reliability of laser Doppler flowmetry, pulse oximetry and electric pulp tester in assessing the pulp vitality of human teeth. *J Oral Rehabil* 2011; 38(5):340–7.
7. Siddheswaran V, Adyanthaya R. Pulse oximetry: a diagnostic instrument in pulpal vitality testing - an in vivo study. *World J Dent* 2011; 2(3):225–30.
8. Gopikrishna V, Tinagupta K, Kandaswamy D. Evaluation of efficacy of a new custom-made pulse oximeter dental probe in comparison with the electrical and thermal tests for assessing pulp vitality. *J Endod* 2007; 33(4):411–4.
9. Bedoya M., Park J. A Review of the Diagnosis and Management of Impacted Maxillary Canines. *J. Am. Dent. Assoc.* 2009;140:1485–1493.
10. Mainkar A., Kim S. Diagnostic Accuracy of 5 Dental Pulp Tests: A Systematic Review and Meta-analysis. *J. Endod.* 2018;44:694–702.
11. Goho C. Pulse oximetry evaluation of vitality in primary and immature permanent teeth. *Pediatric Dentistry.* 1999;21:125–27.
12. Gopikrishna V, Tinagupta K, Kandaswamy D. Comparison of electrical, thermal, and pulse oximetry methods for assessing pulp vitality in recently traumatized teeth. *Journal of Endodontics.* 2007;33(5):531–35
13. Setzer FC, Kataoka SH, Natrielli F, Gondim-Junior E, Caldeira CL. Clinical diagnosis of pulp inflammation based on pulp oxygenation rates measured by pulse oximetry. *Journal of Endodontics.* 2012;38(7):880–83.
14. Anusha B, Madhusudhana K, Chinni SK, Paramesh Y. Assessment of Pulp Oxygen Saturation Levels by Pulse Oximetry for Pulpal Diseases -A Diagnostic Study. *J Clin Diagn Res.* 2017 Sep;11(9):ZC36-ZC39.
15. Molaasadolah F, Zargar N, Bargrizan M, Akbari F, Kardouni Khozestani P, Sabour S, Bakhshi M (2022) Comparison of pulse oximeter, cold test, and electric pulp test for assessment of pulp vitality in permanent immature teeth. *Folia Medica* 64(1): 134-142.
16. Peters D., Baumgartner J., Lorton L. Adult pulpal diagnosis. I. Evaluation of the positive and negative responses to cold and electrical pulp tests. *J. Endod.* 1994;20:506–511.
17. Pantera E., Anderson R., Pantera C. Reliability of electric pulp testing after pulpal testing with dichlorodifluoromethane. *J. Endod.* 1993;19:312–314.
18. Dastmalchi N., Jafarzadeh H., Moradi S. Comparison of the Efficacy of a Custom-made Pulse Oximeter Probe with Digital Electric Pulp Tester, Cold Spray, and Rubber Cup for Assessing Pulp Vitality. *J. Endod.* 2012;38:1182–1186.
19. Janani K., Palanivelu A., Sandhya R. Diagnostic accuracy of dental pulse oximeter with customized sensor holder, thermal test and electric pulp test for the evaluation of pulp vitality: An in vivo study. *Braz. Dent. Sci.* 2020;23:1–8.
20. Sharma A., Madan M., Shahi P., Sood P., Shahi N. Comparative Study of Pulp Vitality in Primary and Young Permanent Molars in Human Children with Pulse Oximeter and Electric Pulp Tester. *Int. J. Clin. Pediatr. Dent.* 2015;8:94–98.
21. Samuel S., Thomas A., Singh N. A comparative study of pulse oximetry with the conventional pulp testing methods to assess vitality in immature and mature permanent maxillary incisors. *CHRISMED J. Health Res.* 2014;1:235–240.
22. Janani K, Palanivelu A, Sandhya R. Diagnostic accuracy of dental pulse oximeter with customized sensor holder, thermal test and electric pulp test for the evaluation of pulp vitality: an in vivo study. *Braz Dent Sci* 2020; 23(1):8-p.

23. Janani K, Ajitha P, Sandhya R, et al. Efficiency of new custom-made pulse oximeter sensor holder in assessment of actual pulp status. *J Family Med Prim Care* 2020; 9(7):3333–7.
24. Gopikrishna V, Tinagupta K, Kandaswamy D. Evaluation of efficacy of a new custom-made pulse oximeter dental probe in comparison with the electrical and thermal tests for assessing pulp vitality. *Journal of Endodontics*. 2007;33(4):411–14.