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Original Article

Comparison of Pulse Oximeter, Cold Test, and Electric Pulp Test for Assessment of Pulp Vitality in Permanent Immature Teeth

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Abstract

Introduction: Pulp sensitivity tests are commonly used for assessment of pulp vitality. However, indirect assessment of pulp vitality by evaluation of nerve response and subjective nature are the main limitations of these tests. Pulse oximetry is used for assessment of blood oxygen saturation in medicine, and its efficacy for assessment of pulp vitality needs to be evaluated.

Aim: This study aimed to assess and compare the efficacy of pulse oximeter with a modified probe, cold test, and electric pulp test for evaluation of pulp vitality in permanent immature teeth.

Materials and methods: This cross-sectional study was conducted on 240 permanent maxillary incisors in four groups based on the type of tooth (central and lateral incisors) and degree of root development (complete or incomplete). Also 40 endodontically treated central and lateral incisors teeth in two groups were evaluated as negative controls. 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, positive likelihood ratio, negative likelihood, diagnostic accuracy, and diagnostic odds ratio were calculated.

Results: 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.

Conclusions: The findings of this study showed that 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 and should be introduced as a suitable method for this purpose and preferred to the cold and electric pulp tests for more evaluation to diagnose pulp vitality.

Keywords

dental pulp, electric pulp test, vitality test, thermal pulp test, pulse oximetry, tooth pulp

INTRODUCTION

Vitality of the pulp is very important for the survival of the tooth as it provides nutrition and acts as a biosensor to detect pathogenic stimuli.[1]

Dental pulp is unique in terms of innervation and microcirculation. The complex anatomy and inaccessibility of dental pulp for direct examination make it difficult for the clinician to accurately detect the pulp status in terms of vitality.[2]

An ideal pulp test must be simple, objective, standard, reproducible, reliable, painless and low-cost. Several tests are available for assessment of pulp vitality. A subgroup of these tests are the pulp sensitivity tests including the electric pulp test (EPT), the cold test, heat test, cavity preparation test and the anesthesia test. However, the main limitation of these tests is that they assess the neural response of dental pulp while the main indicator of pulp vitality is its blood supply.[3] Moreover, efficacy of these tests depends on the presence of adequate number of mature neurons in the pulp tissue.

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.[4,5] 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.[6]

Laser Doppler flowmeter was introduced more than 20 years ago as an alternative method for assessment of pulp vitality. However, it is not routinely used in dental clinical settings due to the high cost, the advanced equipment it requires, the time consuming nature and high technical sensitivity. The pulse oximeter is another modality for detection of pulp vitality which provides an objective estimate of the blood circulation of dental pulp. Its mechanism is not related to the development of nervous system and does not cause any stimulation. Thus, it allows more accurate assessment of the pulp tissue in immature teeth.[7]

Evidence shows that it is non-invasive, completely objective and painless and directly assesses the blood oxygen saturation level. Moreover, it is easily accessible in dental clinics.[2,8,9]

However, the vitality of dental pulp can be assessed by the presence of pulp blood supply and not by the neural responses performed on routine pulp tests. Immature dental pulp is not sufficiently innervated while it has sufficient blood supply. It is necessary to diagnose tooth vitality without aggressive method in order to prevent invasive management.[9]

AIM

This study aimed to assess and compare the diagnostic accuracy of conventional pulp tests: EPT, the cold test and pulse oximeter with a custom made probe for this purpose for the assessment of pulp vitality in immature permanent teeth.

MATERIALS AND METHODS

This cross-sectional study was conducted in 120 patients aged 7-13 years[10] with immature vital maxillary central and lateral incisors referring to the Pediatric Dentistry Department. The teeth were selected using convenience sampling. A total of 240 sound teeth were evaluated. For easier assessment, the teeth were divided into four groups of central incisors with incomplete root (IC), central incisors with complete root (CC), lateral incisors with incomplete root (IL), and lateral incisors with complete root (CL) with 60 teeth in each group. Patients should have panoramic radiographs to determine the stage of root development. The root developmental stage was determined on panoramic radiographs of patients as explained by a previous study.[11] **Fig. 1A** shows incisors with complete roots and **Fig. 1B** - incisors with incomplete roots. Twenty endodontically treated central and 20 lateral incisors were also evaluated as the negative control group.

The inclusion criteria were no systemic disease, having sound, immature permanent maxillary central and lateral incisors with three-fourth or the entire root length formed, clinically sound crowns, no caries, fracture, restoration or discoloration, and no history of maxillofacial traumas.

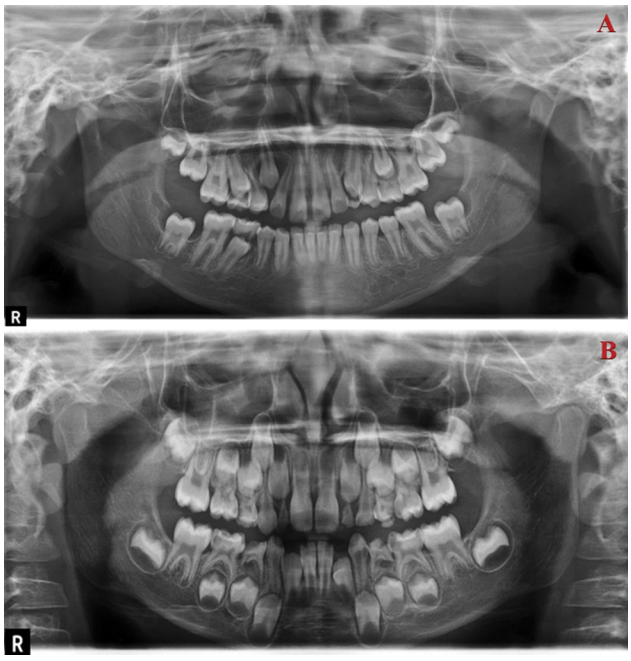

Figure 1. The root developmental stage was determined on panoramic radiographs of patients; **A**. incisors with complete root (CL); **B**. incisors with incomplete root.

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The exclusion criteria were children with a history of systemic vascular or cardiovascular disease and medication use (sedatives, narcotics, and tranquilizers), inability to respond to pulp testing (mental retardation), and presence of developmental or structural defects in the respective teeth, presence of pain, inflammation or periodontal disease and not being able to correctly place the pulse oximeter probe.

The gold standard was considered according to the clinical and radiographic findings. The respective tooth was isolated using cotton rolls and then the pulse oximeter test and after that, the cold test and EPT were performed as follows with 5-minute intervals by the same examiner.[12]

The pulse oximeter used in this study was *Alborz B5* (*Masimo SET/SAADAT*, *Iran*) and the *FMT-RAF-MSM-L sensor* (*Metko Ltd,. Istanbul*, *Turkey*) which had a modified shape for use on teeth **(Figs 2, 3)**.[11]

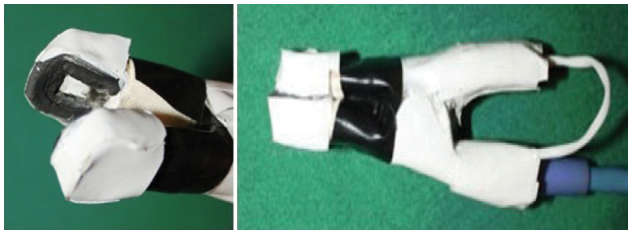

Figure 2. Custom-made sensor holder (Courtesy of Dr. Bargrizan).

Figure 3. Sensor holder on patient's tooth (Courtesy of Dr. Bargrizan).

The patients were instructed not to move their head during the test. A disposable clear plastic cover was used for the sensor. The patient's lips were retracted and the tooth was isolated by cotton rolls. The sensor was placed on the respective tooth so that the sending diode was on the buccal surface and the receiving diode was on the palatal surface as parallel. During the test, the probe was maintained still. The oxygen saturation rate displayed on the monitor after a minimum of 15 seconds was recorded in percentages. If the displayed value was still changing after 15 seconds, the sensor was maintained on the site un til the displayed value remained constant or for a maximum of one minute. The oxygen saturation rate in the range of 80%–100% was considered as a positive response.[11] During testing, strong fluorescent light was prevented since it could interfere with the results.

Cold spray (Teste de Vitalidade Endo Ice, Maquira, Germany) was used for the cold test. The respective tooth was isolated with cotton rolls. A cotton pellet, sprayed for a couple of seconds with the cold spray at a distance of 5 mm was placed over the buccal middle-third of the respective tooth and the patient was asked to raise his/her hand whenever they felt the stimulant. The response to the cold test was considered positive if the patient responded within the first 15 seconds and negative in case of no response within the first 15 seconds.[13]

For the electric pulp test we used an electric pulp tester (Parkell Inc, Edgewood, New York). To prevent false responses, the respective tooth was dried and isolated with cotton rolls. The patient was instructed to raise his hand whenever he felt the stimulation. Pumice paste was used as the intermediate material to transfer electrical pulse energy. The electrode was placed at the incisal third of the tooth[14] and the intensity of the device was gradually increased (by 1° every 5 seconds) until the patient felt the stimulation. Any response was considered as a positive response and no response was considered as a negative response.[2]

Pulse oximetry, cold test and EPT were also performed for 40 endodontically treated central and lateral incisors as the negative controls.

The study objective was thoroughly explained to the patients and their parents and written informed consent was obtained from the parents.

The study protocol was approved by the ethics committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (code: IR.SBMU.RIDS.REC.1394.107).

Statistical analysis

In this study, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), negative likelihood ratio (LR-), diagnostic accuracy, and diagnostic odds ratio have been used to evaluate the pulse oximeter, cold test and electric pulp test for assessment of pulp vitality in permanent immature teeth. The statistical analysis was conducted by using R software (version 4.0.4). According to the sample size formula for one proportion

$$(\mathrm{n}=Z_{1-\frac{\alpha}{2}}P(1-P)/d^2)$$

the sample size was estimated at 280 teeth based on specificity equal to 0.82 (P), type I error 0.05 (α), and effect size of 0.05 (d).[15]

RESULTS

Permanent central incisors with three-fourth of the root length formed

Pulse oximeter test correctly diagnosed all 60 vital teeth as vital (true negative). The cold test diagnosed 48 teeth as vital (true negative) and 12 as non-vital (false positive). EPT diagnosed 41 teeth as vital (true negative) and 19 as non-vital (false positive). In endodontically treated teeth, pulse oximeter diagnosed 19 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 95% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter was 100% and 98.3%, respectively. Thus, in 100% of the cases, no response to pulse oximeter (LR+) indicated a non-vital tooth and in 98.3% of the cases, positive response to pulse oximeter (LR-) indicated a vital tooth. Thus, the diagnostic odds for the pulse oximeter were infinite. **Table 1** shows the comparison of diagnostic parameters for the pulse oximeter, EPT and cold test in permanent central incisors with three-fourth of the root length formed. As shown, pulse oximeter was the most accurate test followed by the cold test and EPT.

Permanent central incisors with complete root length formed

The pulse oximeter test correctly diagnosed all 60 vital teeth as vital (true negative). Fifty-four teeth responded to the cold test and EPT (true negative); six vital teeth did not respond to EPT or cold test (false positive). In endodontically treated teeth, pulse oximeter diagnosed 19 teeth to be non-vital (true positive) and one tooth as vital (false negative). Cold test and EPT detected all endodontically treated teeth to be non-vital (true positive). Pulse oximeter had the highest diagnostic accuracy with 95% sensitivity and 100% specificity. The PPV and NPV for pulse oximeter were 100% and 98.3%, respectively. Thus, in 100% of the cases, no response to pulse oximeter (positive test result) indicated a non-vital tooth and in 98.3% of the cases a positive response to pulse oximeter test (negative test result) indicated a vital tooth. The diagnostic odds for pulse oximeter were infinite. **Table 2** shows the comparison of diagnostic parameters for the pulse oximeter, EPT and cold test in permanent central incisors with complete root length formed. In permanent central incisors with complete root length formed, pulse oximeter was more accurate than the other two tests. Cold test and EPT had the same level of accuracy.

Permanent lateral incisors with three-fourth of the root length formed

Pulse oximeter test correctly diagnosed all 60 vital teeth as vital (true negative), while the cold test correctly diagnosed 53 teeth and EPT correctly diagnosed 41 teeth. In other words, seven vital teeth did not respond to cold test (false positive) and 19 vital teeth were falsely diagnosed as non-vital by EPT (false positive). In endodontically treated teeth, all three tests diagnosed endodontically treated teeth as non-vital (true positive), indicating 100% sensitivity of all three tests. The EPT test in these teeth showed the least specificity (68.3%). In other words, the possibility of positive response to EPT test in immature vital teeth was 68.3% (true negative). The PPV for EPT test was the lowest (51.2%). Thus, 50% of the teeth that did not respond to EPT were actually non-vital. **Table 3** shows the comparison of diagnostic parameters for the pulse oximeter, EPT, and the cold test in permanent lateral incisors with three-fourth of the root length formed. The pulse oximeter had a higher accuracy than the cold test and the cold test was more accurate than EPT for assessment of vitality of permanent lateral incisors with three-fourth of the root length formed.

Permanent lateral incisors with complete root length

The pulse oximeter test correctly diagnosed all 60 vital teeth as vital (true negative) while the cold test correctly diagnosed 51 teeth (true negative) and nine teeth did not respond to this test (false positive). EPT falsely diagnosed 13 teeth as non-vital (false positive), while 47 teeth were correctly diagnosed as vital by EPT (true negative). All three tests showed 100% sensitivity in endodontically treated teeth. EPT had the lowest specificity and PPV (78.3% and 60.6%, respectively). EPT showed lower accuracy than the cold test and pulse oximeter, while the pulse oximeter showed the highest accuracy with 100% sensitivity, specificity, PPV, and NPV. **Table 4** shows the comparison of diagnostic parameters for the pulse oximeter, EPT, and cold test in permanent lateral incisors with complete root length formed. In permanent lateral incisors with complete root length, the pulse oximeter was more accurate than the cold test which was more accurate than EPT.

DISCUSSION

This study assessed the efficacy of pulse oximeter with a modified probe for assessment of pulp vitality in comparison with cold test and EPT in permanent immature incisor teeth. The results showed that for permanent central incisors with three-fourth of the root length formed, lateral incisors with three-fourth of the root length formed and lateral incisors with complete root length, the pulse oximeter was more accurate than the cold test and the latter was more accurate than EPT. In permanent central incisors with complete root length, the cold test and EPT performed the same in terms of accuracy and both were less accurate than the pulse oximeter. Thus, it may be concluded that in all groups, pulse oximetry was more accurate than the cold test and EPT.

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	95%	100%	100%
Specificity	100%	68.3%	80%
Positive predictive value	100%	51.2%	62.5%
Negative predictive value	98.3%	100%	100%
Diagnostic accuracy	98.7%	76.2%	85%
Positive likelihood ratio	Infinite	3.15	5
Negative likelihood ratio	0.05	0.0	0.0
Diagnostic odds ratio	Infinite	Infinite	Infinite

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

Parameter	Pulse oximeter	EPT	Cold test
Sensitivity	95%	100%	100%
Specificity	100%	90%	90%
Positive predictive value	100%	76.9%	76.9%
Negative predictive value	98.3%	100%	100%
Diagnostic accuracy	98.7%	92.5%	92.5%
Positive likelihood ratio	Infinite	10	10
Negative likelihood ratio	0.05	0.0	0.0
Diagnostic odds ratio	Infinite	Infinite	Infinite

Table 3. Comparison of diagnostic parameters for the pulse oximeter, EPT, and cold test in permanent lateral incisors with three-fourth of the root length formed

Parameter	Pulse oximeter	EPT	Cold test
Sensitivity	100%	100%	100%
Specificity	100%	68.3%	88.3%
Positive predictive value	100%	51.2%	74.1%
Negative predictive value	100%	100%	100%
Diagnostic accuracy	100%	76.2%	91.2%
Positive likelihood ratio	Infinite	3.1	8.5
Negative likelihood ratio	0.0	0.0	0.0
Diagnostic odds ratio	Infinite	Infinite	Infinite

Table 4. Comparison of diagnostic parameters for the pulse oximeter, EPT, and cold test in permanent lateral incisors with complete root length

Parameter	Pulse oximeter	EPT	Cold test
Specificity	100%	78.3%	85%
Positive predictive value	100%	60.6%	68.9%
Negative predictive value	100%	100%	100%
Diagnostic accuracy	100%	83.7%	88.7%
Positive likelihood ratio	Infinite	4.6	6.6
Negative likelihood ratio	0.0	0.0	0.0
Diagnostic odds ratio	Infinite	Infinite	Infinite

Correct diagnosis is fundamental for a successful dental treatment. This is especially important in traumatic injuries because accurate assessment of the injured tissue may eliminate the need for invasive treatments and further trauma to the tooth. Diagnostic tests can greatly help in this respect.[8]

As the prevalence of trauma to immature teeth is high, this study evaluated the accuracy of pulp vitality assessment by pulse oximetry compared to EPT and a cold test in central and lateral incisors with completely formed and partially formed roots. Assessment of the root developmental stage was done according to Moorrees et al.[16] and Bargrizan et al.[11]

In our study, the sensitivity of EPT was 95% for non-vital teeth and groups IC and CC. This value was 100% for groups IL and CL. The pulse oximeter had 100% specificity in all groups. It means that all vital teeth gave a positive response to the pulse oximeter. However, this rate was 80-90% for the cold test and 68-90% for the EPT. Gopikrishna et al.[6] in their study on 80 mature incisors, canines, and premolars reported that pulse oximeter had 100% sensitivity and 95% specificity. The sensitivity of the cold test and EPT was 81% and 71%, respectively, and their specificity was 92%. Sharma et al. showed that thermal pulp test and pulse oximetry accuracy was 100% and this was 90% in electrical pulp test for permanent and 86.67% for primary teeth.[17] In a study by Dastmalchi et al.[18] on 24 mature mandibular premolars, the sensitivity of pulse oximeter, cold test, and EPT was 93%, 53%, and 60%, respectively. Their specificity was 100%, 55%, and 22%, respectively. In a study by Samuel et al.[2] on immature maxillary incisors, the sensitivity of pulse oximeter, cold test, and EPT was 90%, 93%, and 96%, respectively. Their specificity was 100%, 100%, and 80%, respectively.

Janani et al.[8] 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.[19]

Most studies showed that specificity of pulse oximeter is often higher than that of cold test and EPT.[8,9,11,19-22] But Karayilmaz and Kirzioglu[4] in their study on 59 maxillary incisors showed that the sensitivity of pulse oximeter and EPT was 81% and 91%, respectively, while their specificity was 94% and 88%, respectively. Their results in terms of sensitivity were different from ours. The reason for the lower sensitivity of pulse oximeter can be the presence of false positive responses of non-vital teeth to the test due to fluorescent light interferences from the environment or problems in probe adaptation to the tooth or movement artifact.[23]

A false negative response, which means no response of vital tooth to the test, was seen for both the cold test and EPT. This results in errors in diagnosis and treatment planning and is worse than a false positive result. However, the pulse oximeter correctly diagnoses all vital teeth, which is a highly important advantage especially for assessment of immature teeth.

The specificity of pulse oximeter in previous studies and the current one was between 94%–100% with a sensitivity in the range of 81%–100%. The difference in the results of the studies may also be attributed to different definitions of sensitivity and specificity. Sensitivity refers to the ability of a test to correctly diagnose the disease (which was pulp necrosis in our study) and no response to pulp test.[6,12,18,24] However, some previous studies defined sensitivity for pulp test as the positive response of vital pulp to pulp sensitivity test.[25,26] Therefore, this issue must be taken into account when comparing the results of studies.

Most previous studies have focused on sensitivity and specificity of tests, but PPV and NPV are also important for clinical use of a diagnostic test.[8,15,17] In the assessment of these values, the prevalence of the disease is important because these values change with prevalence.[13] The prevalence was 52% in the study by Gopikrishna et al.[6], 39% in the study by Peterson et al.[26], and 25% in our study. Due to a difference in prevalence, our results regarding PPV and NPV are different from those of previous studies; therefore, accurate comparison cannot be made. The prevalence of severe inflammation of the pulp or necrosis was high in most previous studies because most of these studies had been performed on patients referred for endodontic treatment or extraction. The results of such studies have an inherent risk known as the spectrum bias, which indicates that the study population may not be a true representative of patients in the clinical setting in daily practice.[27,28] In our study, PPV was 100% for the pulse oximeter for the four groups. This value was between 62% to 76% for the cold test and 51% to 76% for EPT. The NPV was 98.3% to 100% for pulse oximeter and 100% for the cold test and EPT. In previous studies, this value was reported to be in the range of 92% to 100% for pulse oximeter, which was higher than the value for the cold test and EPT; however, the values for the cold test and EPT have been widely variable in different studies.[2,6,8,12,17,24,25] The discrepancy in the results of studies may be attributed to different methodologies, control of confounding factors, sample size, type of tooth, and age of patients. Patient's age is an important factor affecting the results. Most previous studies excluded children since their response may not be accurate. However, a major indication of diagnostic pulp tests is for children with traumatized immature teeth. The pulp tissue in these teeth has a high potential for regeneration. On the other hand, tooth loss at this age can have serious consequences. Therefore, it is imperative to correctly diagnose the pulp status in such teeth. An appropriate test must be painless and objective. This is highly important for pediatric patients due to their poor cooperation especially in cases of trauma.[29] Pulse oximeter can be useful for such teeth since the cold test and EPT are not much reliable in such cases.

Accuracy of a test is another important factor. The accuracy of a pulse oximeter is excellent given that the oxygen saturation rate is between 80%–100% and the blood hemoglobin is reduced hemoglobin or oxygenated hemoglobin. The accuracy of this device is doubtful in cases of presence

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of carboxyhemoglobin or methemoglobin.[30] In our study, the accuracy of pulse oximeter was 98.7% in groups IC and CC and 100% in groups IL and CL. This value was 76.2%–92.5% for EPT and 85% to 92.5% for the cold test. The pulse oximeter was more accurate than the cold test and the latter was more accurate than EPT. This result is consistent with the results of some previous studies.[14,24]

Easy use in clinical settings, low cost, and non-invasiveness are other important factors that need to be taken into account when assessing the efficacy of a diagnostic test.

Despite the common use of a pulse oximeter in medicine, it is not routinely used in dentistry. The most important issue with regard to the use of this device in dentistry is designing a special probe that perfectly matches the tooth anatomy. No such probe is commercially available and this is a major limitation in use of pulse oximeter in dentistry. It is critical to fabricate a sensor that matches tooth anatomy in terms of size and shape such that the LED and photo-detector are positioned parallel while the probe is fixed on the tooth surface with no movement.[31] Movement of probe on the tooth surface is a common artifact. One solution is to record the mean signal over time. The longer the duration, the lower the artifact would be.[18] Rubber dam clamp can also be used to decrease movement of probe. Noblett et al.[32] used a rubber dam clamp as a basis for designing the sensor. Kahan et al.[33] designed a reflectance probe which did not have a predictable diagnostic value. We modified the finger probe for use on teeth in our study and tried our best to adapt it to the tooth anatomy and immobilize it. We used black Styrofoam and PVC for this purpose to prevent light reaching the sensor. Flexibility of Styrofoam caused better adaptation of sensor to tooth.

Another limitation with regard to the use of pulse oximeter is the presence of systemic conditions in patients. Increased acidity and metabolism due to inflammation cause deoxygenation of blood and change the oxygen saturation rate. Increased venous pulsation, hemoglobin diseases or body movement can cause errors in the value displayed. Normal arterial blood flow is required for the pulse oximeter to show an accurate result. If the arterial blood flow decreases, the results would not be reliable. This occurs in case of hypothermia, hypovolemia or severe peripheral vasoconstriction. Also, high level of carbon dioxide in blood can interfere with hemoglobin oxygenation rate. Another limitation for a diagnosis of a vital pulp may be encountered in patients with calcification of coronal pulp; this may cause false negative response to the test.[18,34] Measurements of blood pressure of the adjacent tooth may also result in false responses. However, overall, this method seems to be accurate and painless. Thus, designing a probe for dental use can highly increase its popularity for use in the clinical setting.

Requiring a radiography for determination of developmental stage of the root and difficulty in placement of probe in malposed or crowded teeth were among the limitations encountered in conduction of this study. Future longitudinal studies are required to assess the validity of pulse oximeter for teeth with a history of recent trauma.

CONCLUSIONS

Pulse oximetry was more accurate than the cold test and EPT for the assessment of pulp vitality in permanent immature teeth. As maintaining the tooth pulp vitality is important, pulse oximetry seems to be an accurate objective method of preventing an invasive root canal treatment.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Сравнение пульсового оксиметра, холодового теста и электрического пульпового теста для оценки жизнеспособности пульпы в недоразвитых постоянных несформированных зубах

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Резюме

Введение: Тесты на чувствительность пульпы часто используются для оценки жизнеспособности пульпы. Однако основными ограничениями этих тестов являются косвенная оценка жизнеспособности пульпы путём оценки нейронного ответа и его субъективного характера. Пульсоксиметрия используется для оценки насыщения крови кислородом в медицине, и её эффективность в оценке жизнеспособности пульпы должна быть оценена подобающим образом.

Цель: Целью данного исследования является оценка и сравнение эффективности пульсоксиметра с модифицированным датчиком, термоодонтодиагностики с холодовым агентом (Cold-test) и электрического тестера пульпы для оценки жизнеспособности пульпы постоянных несформированных зубов.

Материалы и методы: Это секционное исследование было выполнено на 240 постоянных верхних резцах в четырёх группах, разделённых по типу зубов (центральные и латеральные резцы) и степени развития корней (полные, неполные). Кроме того, 40 эндодонтически пролеченных центральных и латеральных резцов были разделены на две группы и играли роль отрицательного контроля. Жизнеспособность пульпы оценивал опытный клиницист с использованием пульсоксиметра, холодового теста и электрического тестера пульпы. На основе истинных и ложноположительных и отрицательных ответов рассчитывали чувствительность, специфичность, положительную прогностическую ценность, отрицательную прогностическую ценность, отношение положительной вероятности, отношение отрицательной вероятности, диагностическую точность и отношение диагностической вероятности.

Результаты: Пульсоксиметр показал диагностическую точность 98.7% для постоянных центральных резцов с полным и неполным развитием и 100% для постоянных боковых резцов с полным и неполным развитием. Диагностическая точность электрического теста пульпы составила 76.2% и 92.5% соответственно для постоянных центральных резцов с завершенным и неполным развитием и 76.2% и 83.7% для постоянных боковых резцов с завершенным и неполным развитием соответственно. Холодовой тест имел диагностическую точность 85% и 92.5% для полных и неполностью развитых центральных резцов, соответственно, и 91.2% и 88.7% для полных и неполностью развитых боковых резцов соответственно.

Заключение: Результаты этого исследования показали, что пульсоксиметрия имеет более высокую специфичность и лучшую точность, чем холодовый тест и электрический тест пульпы, при оценке жизнеспособности пульпы для диагностики витальных зубов и должна быть внедрена в качестве подходящего метода для этой цели. и предпочтительнее холодового теста и электрического теста пульпы для диагностики жизнеспособности.

Ключевые слова

пульпа зуба, электротест пульпы, тест жизнеспособности, термотест пульпы, пульсоксиметрия, пульпа зуба