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The evaluation of pulse oximetry measurement in determining the health status of pulp in primary molar teeth

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Purpose: The purpose of this study is to establish whether there is any correlation between the health status of pulp and the oxygen saturation values measured by pulse oximetry in primary molar teeth. It is aimed to evaluate the effectiveness of the oxygen saturation values in diagnosing the pulp status.

Methods: The study was conducted on 95 lower second primary molar teeth from 77 patients (aged between 6–9 years). Teeth were assigned into four groups: healthy pulp (positive control, n = 25), reversible pulpitis (n = 25), irreversible pulpitis (n = 25), and negative control (n = 20). The oxygen saturation levels of all teeth in the four groups were measured using pulse oximetry.

Results: The paired comparisons revealed that the positive control group had a higher average value compared to the pulpitis groups (reversible and irreversible; $p < 0.001$). There was no significant difference between the reversible and irreversible pulpitis groups ($p = 0.275$).

Conclusion: Pulse oximetry can be used for the distinction of healthy pulp and pulpitis; however, the stage of the pulpitis cannot be determined through this method in primary molar teeth.

Keywords: Diagnosis; inflammation; primary teeth; pulse oximetry; pulpitis.

Introduction

The pathological status of the pulp must be correctly diagnosed so that the treatment method can be accurately determined in teeth with deep dentin caries and affected pulp (1-3). In current clinical practice, this is performed through vitality tests in addition to extensive medical history, extraoral, intraoral, and radiographic examinations (4).

The vitality tests commonly used for the diagnosis of the pulpal status are only able to provide subjective information about the neural status of the pulp but no information about the vascular structure of the tooth. During inflammatory processes, the neural structures of the pulp are more resistant to infections compared to vascular structures. Thus, false-positive results can be obtained from a conventional vitality test due to intact nervous tissue, although inflammation has started in the pulp. Furthermore, the difficulty of performing such tests, especially in young children, the inability of children to describe subjective symptoms, and the fear of painful stimuli in children can limit the use of conventional pulp tests (5-9).

Another commonly used criterion for determining a healthy dental pulp is the characteristics of pulpal bleeding (the amount, duration, and quality of the bleeding) (10-

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12). However, among the criteria for the characteristics of pulpal bleeding, only the duration of bleeding is an objective finding. Also, recent studies indicate that hemostasis may not be an accurate indicator of dental pulp condition (10,13,14).

The combined result of the inaccuracy of vitality tests and the subjectivity of the operative diagnostic methods makes it difficult to make a definite diagnosis in primary teeth. In recent years, researchers have focused on developing a new method that can directly provide information regarding the vascularization of the tooth for the diagnosis of the pulp (5,7,9). Several studies have tried to develop a non-invasive (15), practical, reliable, and reproducible method (7). Pulse oximetry (PO) has come to prominence among these practical methods in dentistry.

Researchers indicate that the pulse oximetry method can be used to determine the vitality of primary and permanent teeth. Also, it is suggested that the obtained oxygen saturation (SaO_2) levels can be used to establish the diagnosis/prognosis of dental pulp pathologies (6,8,16,17). The current literature suggests that pulse oximetry can successfully diagnose the status of the dental pulp (17,18).

Although there are prior studies conducted on permanent teeth on the topic (15-17), it is unclear whether this method is effective for the diagnosis of the pathological status of primary teeth. In light of this data, this study aims to determine the possible relationship between the oxygen saturation levels (measured with the pulse oximeter) and the pathological condition of the dental pulp in primary molar teeth. Our null hypothesis was that there was no relationship between oxygen saturation levels and pulpal status of primary teeth.

Materials and Methods

Ethical Approval

Ethical approval for this study was obtained from the Ethical Committee for Clinical Research, Kırıkkale University, Kırıkkale, Türkiye (Date: 04/04/2017, No:2017–09/05). Before the procedure, all patients and their parents were informed about the study and signed informed consent forms after the necessary permits were obtained. The study was conducted under the principles of the Declaration of Helsinki.

Patient Selection, Inclusion, and Exclusion Criteria

This in vivo study was conducted on lower second primary molars of patients with parental cooperation, aged between 6–9 years old, and without any systemic diseases who were referred to K.U. Department of Pedodontics between April 2017 and October 2017.

Cooperated patients with intact crowns on the lower second primary molars were involved in the study to measure the oxygen saturation of the pulp. The exclusion criteria were as follows: teeth with brackets, bands, or crowns; discoloration (due to fluorosis, trauma, etc.); hypoplasia; hypocalcification or trauma; cervical defect that prohibits measurement; unhealthy periodontium or root resorption; and teeth diagnosed with the aforementioned defects during the procedure were excluded from the study to provide more reliable and standard results.

The Formation of the Study Groups

The power analysis revealed that the required number of teeth was 19 for each group (95% confidence interval, 0.4 effect size) for the study that was planned to include 2 study and 2 control groups (76 teeth in total; $\alpha = 0.05$, Power = 0.80).

Considering possible dropouts during measurements, the study was conducted on a total of 95 primary mandibular second molar teeth. The groups and the teeth to be included in the study were determined based on the data obtained from the anamnesis, together with the clinical and radiographic examinations. Both the anamnesis and clinical examination were performed by the same researcher (T.S.).

The study groups, their inclusion criteria, and the number of teeth assigned to each group were as follows:

1. Healthy Pulp (HP): Healthy teeth without caries, fractures, structural deformities (hypoplasia, hypocalcification), any pathological findings affecting the pulp, any signs, symptoms, radiologic pathology, or any sign of physiological root resorption on X-rays obtained with parallel technique.

2. Reversible Pulpitis (RP): Teeth having a carious lesion that is very close to the dental pulp without spontaneous pain. No percussion or palpation sensitivity complaints. Presence of sharp pain that is provoked by thermal and other stimuli that disappears after stimulus removal. Absence of pathological mobility or any pathological findings in the surrounding soft tissues (color changes, fistulas, or swelling). No indication of pathological root resorption, inter-radicular or periapical lesions, or loss of lamina dura in radiographic examination.

3. Irreversible Pulpitis (IP): Teeth with at least two of the following symptoms: severe, spontaneous, prolonged, percussion sensitivity or pathological mobility. No necrotic or gangrenous pulp. No pathologies in the surrounding structures (edema, fistula). No physiological or pathological root resorption or lesion in radiographic examination.

4. Negative Control (ET): Teeth with prior root canal

treatment due to a previous carious lesion. No clinical or radiographic pathologies.

Pulse Oximetry Measurements

The oxygen saturation levels of all teeth in the four groups included in the study were measured using pulse oximetry.

The PO measurements were made with a bedside monitor (Multiparameter Bedside Monitor, MASIMO RADICAL-7, US) and the infant probe compatible with this device (MASIMO Infant Probe, US). Prior to the measurements, the infant probe was modified for application on the children's primary molars. This process was modeled on the probes and probe holders used by Gopikrishna et al. (19-21).

The teeth chosen for the study were isolated with cotton rolls. The sensors were placed on the vestibular and lingual surfaces (so that they were parallel to each other) on the cervical 1/3 of the teeth. After a 30-second wait period, the measured values were recorded.

Statistical Analysis

The SaO_2 measurements were recorded together with the age, gender, clinical diagnosis, and teeth numbers. The data were analyzed using the Statistical Package for the Social Sciences (SPSS) 21.0 software (SPSS Inc., Chicago, IL, USA). Shapiro–Wilk, independent sample t-test, ANOVA, Tukey, Mann–Whitney U, and Spearman correlation tests were used for statistical analysis. A p-value of less than 0.05 was considered statistically significant.

Results

The study included 95 teeth in 77 children (30 females [39%] and 47 males [61%]) aged between 6 and 9 years (mean age: 6.7). Fifty-six (59.6%) out of 95 teeth were primary mandibular right second molars, and the remaining 39 (40.4%) teeth were primary mandibular left second molars.

The mean O_2 saturation levels in study and control groups are presented in Table 1. The mean values were 0 for the negative control group, 90.12 ± 3.50 for the healthy pulp group, 83.52 ± 3.29 for the reversible pulpitis group, and 82.12 ± 2.74 for the irreversible pulpitis group. As the mean O_2 saturation level was 0 for the 20 teeth that had previous root canal treatment (negative control group), they were excluded from the statistical analysis. The paired comparisons between the remaining three groups revealed that the O_2 saturation was higher in the positive control group compared to both reversible and irreversible pulpitis groups ($p < 0.001$). There was no significant difference between reversible and irreversible pulpitis groups ($p = 0.275$).

Discussion

The lack of an accurate diagnostic tool that can diagnose pulp inflammation in primary teeth can lead to failure in pulp therapy (10). Although histological analysis is the "gold standard" in deciding the pathological state of the pulp, it is not possible to perform a histological examination prior to treatment (22), and the current diagnostic methods (clinical and operative methods, vitality tests) are not able to accurately determine the state of the pulp in primary teeth. These factors lead to diagnostic errors, especially when trying to understand the reversibility of the inflammation in the dental pulp.

As current diagnostic methods are insufficient in determining the dental pulp's condition, researchers have started to investigate novel methods that can assess the vascular structure of the dental pulp, and these investigations have focused on pulse oximetry in recent years. There are in vivo and in vitro studies that examine the vitality of the dental pulp through pulse oximetry (6,8,20,23,24). There are also a limited number of studies that examined the relationship between the pathological condition and the oxygen saturation of the dental pulp of permanent teeth (17,18). However, there are no studies conducted on primary teeth on this topic. Thus, this study aimed to evaluate the ability of the pulse oximetry method to determine dental pathologies in primary teeth.

Table 1. Comparison of SaO_2 levels in study and control groups. Values with the same letters indicate statistical significance

	Mean ± SD	Min-Max	Median
Healthy Pulp (Positive Control) (n=25)	90.12 ± 3.50a,b	85-96	90
Reversible Pulpitis(n=25)	83.52 ± 3.29a	77-90	84
Irreversible Pulpitis(n=25)	82.12 ± 2.74b	78-88	82
Teeth with Root Canal Treatment (Negative Control) (n=20)	-	0-0	0

*The significant differences are shown with different superscript capital letters and lowercase letters in column and row, respectively.

Similar to previous studies (5,17,20,24), in the present study, the pulse oximetry results obtained from root canal treatment performed teeth were recorded as 0, confirming that oxygenation or pulse data cannot be obtained from teeth without vascular support.

According to the results of the present study, it was found that the SaO_2 values were significantly higher in the positive control group compared to both the reversible and irreversible pulpitis groups. This indicates that the vascularity and blood support decrease in case of pulpitis and that this change can be measured through pulse oximetry. This finding is compatible with previous research conducted on permanent teeth. Setzer et al. (17) have found the SaO_2 levels to be 92% for healthy teeth, 88% for the reversible pulpitis group, and 83.5% for the irreversible pulpitis group; Anusha et al. (18) have found that these values were 94%, 85%, and 81% for anterior teeth, respectively. For both studies, the SaO_2 levels were significantly higher in healthy teeth.

We found that the SaO_2 levels were higher in the reversible pulpitis group compared to the irreversible pulpitis group. However, this finding was not statistically significant. This finding in contrast with previous research conducted on permanent teeth, where researchers have found that the PO SaO_2 levels were significantly different for the reversible and irreversible pulpitis groups and reported that this finding may be useful for determining the level of inflammation in the dental pulp (17,18). The decreased oxygen saturation in the teeth diagnosed with pulpitis (reversible or irreversible) can be explained by the decreased vascularity in the dental pulp parallel to the degree of inflammation (17). As the PO measurement in our study completely depended on vascularization and blood support, it is possible that similar results to reversible pulpitis could have been obtained from teeth with irreversible pulpitis during the initial phase where the vascular deformation is not severe. Also, as the pulp is more voluminous in permanent teeth, the vascular changes may have been easier to measure in studies where permanent teeth were used. Additionally, since caries lesions progress more quickly in primary teeth due to their histological and anatomical structures and pulp tissue sometimes can be infected before the lesion reaches the dental pulp, reversible pulpitis may turn into irreversible pulpitis before the emergence of clinical symptoms (14,25-27). This may have led to similar saturation level measurements in our study.

One of the limitations of the present study was the standardization of the teeth included in the study. Since the pulp is surrounded by hard tissue the accuracy of the readings can be affected by the thickness of the enamel and dentin, which is hard to standardize in the teeth included. Also, the pulpal status of the teeth included were determined with clinical and radiographic information. Although histological analysis is the gold standard, it was impossible to use due to the nature of the study design. Within the limitations of the present study, in light of our findings, we conclude that the pulse oximetry method can be used to distinguish healthy pulp from pulpitis in primary molar teeth. Thus, pulse oximetry can be used as an assisting method together with clinical symptoms and operative diagnostic methods when deciding the treatment in cases where the caries has penetrated the pulp; however, it was not useful in distinguishing reversible and irreversible pulpitis cases. Further studies are needed to investigate and compare the saturation levels with treatment success rates, which may shed more light on the issue.

Conclusion

Based on this study's findings, the following conclusions can be made:

1. Pulse oximetry can be used as an assisting method when deciding the treatment in cases where the decay has penetrated the pulp.

2. Pulse oximetry was not found to be useful for the distinction between reversible and irreversible pulpitis.

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Informed consent: Written informed consent was obtained from patients who participated in this study.

References

1. Baumgartner J. Pulpal infections including caries. In K. M. Hargreaves, H. E. Goodis, eds. Seltzer and Bender's Dental Pulp. Berlin: Quintessence; 2002, pp. 281-307.
2. Camp J, Fuks A. Pediatric endodontics: Endodontic treatment for the primary and young permanent dentition. In Stephen Cohen, ed. Pathways of the Pulp. St. Louis: Mosby; 2006. pp. 808-874.
3. Fuks AB. Pulp therapy for the primary and young permanent dentitions. Dent Clin North Am 2000; 44(3): 571–96. [CrossRef]

4. Guelmann M. Clinical pulpal diagnosis. In A.B. Fuks, B. Peretz, eds. Pediatric Endodontics. New York City: Springer; 2016. pp. 23-36. [CrossRef]
5. Munshi A, Hegde A, Radhakrishnan S. Pulse oximetry: A diagnostic instrument in pulpal vitality testing. J Clin Pediatr Dent 2003; 26(2): 141–5. [CrossRef]
6. Goho C. Pulse oximetry evaluation of vitality in primary and immature permanent teeth. Pediatr Dent 1999; 21(2): 125–7.
7. Samraj R, Indira R, Srinivasan M, et al. Recent advances in pulp vitality testing. Endodontology 2003; 15(1): 14–9.
8. Schnettler JM, Wallace JA. Pulse oximetry as a diagnostic tool of pulpal vitality. J Endod 1991; 17(10): 488–90. [CrossRef]
9. Gopikrishna V, Pradeep G, Venkateshbabu N. Assessment of pulp vitality: A review. Int J Paediatr Dent 2009; 19(1): 3–15. [CrossRef]
10. Waterhouse P, Whitworth J, Camp J, et al. Pediatric endodontics: Endodontic treatment for the primary and young permanent dentition. In Stephen Cohen, ed. Pathways of the Pulp. St. Louis: Mosby; 2011. [CrossRef]
11. Doğan S, Durutürk L, Orhan A, et al. Determining treatability of primary teeth with pulpal exposure. J Clin Pediatr Dent 2013; 37(4): 345–50. [CrossRef]
12. Orhan AI, Oz FT, Ozcelik B, et al. A clinical and microbiological comparative study of deep carious lesion treatment in deciduous and young permanent molars. Clin Oral Investig 2008; 12(4): 369–78. [CrossRef]
13. Mutluay M, Arikan V, Sari S, et al. Does achievement of hemostasis after pulp exposure provide an accurate assessment of pulp inflammation? Pediatr Dent 2018; 40(1): 37–42.
14. Waterhouse P, Nunn J, Whitworth J. Prostaglandin E2 and treatment outcome in pulp therapy of primary molars with carious exposures. Int J Paediatr Dent 2002; 12(2): 116–23. [CrossRef]
15. Ciobanu G, Ion I, Ungureanu L. Testing of pulp vitality by pulsoximetry. Odontology 2012; 2(2): 94–8.
16. Caldeira CL, Barletta FB, Ilha MC, et al. Pulse oximetry: A useful test for evaluating pulp vitality in traumatized teeth. Dent Traumatol 2016; 32(5): 385–9. [CrossRef]
17. Setzer FC, Kataoka SH, Natrielli F, et al. Clinical diagnosis of pulp inflammation based on pulp oxygenation rates measured by pulse oximetry. J Endod 2012; 38(7): 880–3. [CrossRef]
18. Anusha B, Madhusudhana K, Chinni SK, et al. Assessment of pulp oxygen saturation levels by pulse oximetry for pulpal diseases—A diagnostic study. J Clin Diagn Res 2017; 11(9): ZC36. [CrossRef]
19. Gopikrishna V, Kandaswamy D, Gupta T. Assessment of the efficacy of an indigenously developed pulse oximeter dental sensor holder for pulp vitality testing. Indian J Dent Res 2006; 17(3): 111. [CrossRef]
20. 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. [CrossRef]
21. Gopikrishna V, Tinagupta K, Kandaswamy D. A comparative analysis of pulp vitality tests in primary teeth. J Clin Pediatr Dent 2007; 31(2): 89–94.
22. Flores M, Holan G, Borum M, et al. Injuries to the primary dentition. In J. O. Andreasen, F. M. Andreasen, L. Andersson, eds. Textbook and Color Atlas of Traumatic Injuries to the Teeth. 4th ed. Hoboken: Wiley-Blackwell; 2007. pp. 516-541.
23. Schmitt JM, Webber R, Walker E. Optical determination of dental pulp vitality. IEEE Trans Biomed Eng 1991; 38(4): 346–52. [CrossRef]
24. Pozzobon MH, de Sousa Vieira R, Alves AMH, et al. Assessment of pulp blood flow in primary and permanent teeth using pulse oximetry. Dent Traumatol 2011; 27(3): 184–8. [CrossRef]
25. Kassa D, Day P, High A, et al. Histological comparison of pulpal inflammation in primary teeth with occlusal or proximal caries. Int J Paediatr Dent 2009; 19(1): 26–33. [CrossRef]
26. Ibricevic H, Al-Jame Q. Ferric sulfate as pulpotomy agent in primary teeth: Twenty-month clinical follow-up. J Clin Pediatr Dent 2000; 24(4): 269–72. [CrossRef]
27. Rodd H, Waterhouse P, Fuks A, et al. Pulp therapy for primary molars. Int J Paediatr Dent 2006; 16(s1): 15–23. [CrossRef]