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Evaluation of effectiveness of custom-made pulse oximeter in comparison with other pulp sensibility tests for assessing pulp vitality - A systematic review

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Abstract

Aim: To evaluate the effectiveness of custom-made pulse oximeter in comparison with other pulp sensibility tests for assessing pulp vitality

Materials and Methods: This systematic review was performed according to Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines and was registered at PROSPERO under the number CRD42021239336. The search strategy encompassed the electronic databases and reference lists of articles published until January 2022. We searched the PubMed (Medline), Scopus, Cochrane Library, Google scholar. **Inclusion criteria:** Single-rooted teeth requiring endodontic therapy, teeth requiring intentional endodontic therapy, teeth with irreversible pulpal change.

The data of the included articles extracted, and methodological quality was judged using quality assessment tool following the Cochrane recommendations.

Result: The initial search retrieved 53 potential articles. After removing duplicates, 49 articles remained; after reading titles and abstracts of 49 articles, selection of 21 articles for reading the full text. Five articles were selected for data extraction and qualitative analysis. The vitality test evaluated in the studies was pulse oximetry with sensibility testing. In all articles, the results were favourable for vitality test pulse oximetry.

Conclusion: Diagnostic accuracy of pulse oximeter with custom made sensor holder than other sensibility tests is more accurate and reliable method in assessment of pulp vitality.

Clinical Significance: Assessment of vitality of pulp by evaluating vascular response is necessary along with neural response of pulp tissue.

Keywords: Thermal tests, Pulse oximetry, Pulp vitality.

Introduction

Identification of diseases at their initial stages permits the clinician to initiate the most conservative manage Ment techniques and avoid possible complications and expenses that may arise if a disease is left undiagnosed and untreated for a longer period.

Accurate assessment of the state of the health of the dental pulp, which is a key step for the successful diagnosis of oral diseases, is reached through a detailed patient history, thorough clinical and radiographic examinations and the use of special diagnostic tests (1)

Pulp vitality assessment is a crucial diagnostic procedure in the practice of endodontics and for treating traumatized teeth. The most commonly used tests in practice are thermal tests and electrical pulp tests. A major shortcoming with the present pulp testing methods is that they indirectly monitor pulp vitality by measuring the neural responses and not vascular circulation. The pulpal blood vessels supply and mediate many of the processes of acute and chronic inflammation. Also, the blood supply aids the reparative potential of the pulpal tissues. (2)

Performing Invasive histological study without harming dental pulp is impracticable, non-invasive alternative diagnostic procedures become obligatory, such as pulp vitality tests, which can be subjective or objective.

However, literature suggests pulp vitality tests provide a more accurate indicator of normality or abnormality (3) Thermal and electric pulp tests and are widely used diagnostic tests related to the neurophysiology of the dental pulp.

Pulse oximetry invented by Aoyagi in the early 1970s is an entirely objective test, requiring no subjective response from the patient (4)

This review aims to critically appraise the literature related to the diagnostic accuracy of the most widely used pulp sensibility and pulp vitality tests for determining the pulpal health of permanent teeth in humans.

Also, it attempts to assess the quality of evidence and to explore the implications of these findings for clinical practice and future research planning.

Methods

Protocol and Registration

The present systematic review was registered at the National Institute for Health Research PROSPERO International Prospective Register of Systematic Reviews (registration number: CRD42021239336) on 25/02/2021. This research protocol was designed according to the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) guidelines 2009.

Eligibility Criteria

The eligibility criteria for inclusion of the studies in regard to participants, intervention, comparator, and outcomes are as shown in [Table 1].

The search approach included reference lists and electronic databases for publications published up until January 2022.

Unrestricted searches were allowed in the electronic databases for PubMed (Medline), Scopus, Cochrane Library, and Google Scholar. Additional key words related to the theme of this review were used through the Boolean operators (OR, AND) to combine search words.

- Pulp sensibility tests- Thermal tests, Heat tests, cold test, Electric pulp tests
- Intervention- Pulse oximeter, Dental probe Pulse oximeter, Dental sensor holder pulse oximeter

Study Selection

Title and abstracts of all identified studies were screened independently by two reviewers for eligibility. All studies that met the eligibility criteria were selected for full-text reading.

Full text articles that fulfilled the eligibility criteria were included in the study and processed for data extraction, while reasons for exclusion were recorded. In all steps, lists were compared between reviewers; in case of disagreement, final decisions on inclusion or exclusion were made following discussion with third reviewer

Data collection process

Data collection was performed using a customized data extraction form. Each article was analysed to extract data regarding bibliometric characteristics, methodology, and results.

The following data were extracted: author, country, institution, year of publication, and journal. With regards to study methodology, extracted variables were pulp vitality tests, sensibility test and measurements assessed, patient variables (number, age, and gender), sample number (teeth), type of teeth, and pulse oximeter name and manufacturer.

Regarding study results, pulp vitality results or outcomes were presented as sensitivity and specificity Negative predictive value and Positive predictive value. A qualitative synthesis of the general outcomes of the included studies was also performed

Risk of bias in individual studies.

The risk of bias was performed using the Quality Assessment for Diagnostic Accuracy Studies (Quadas-2)tool. This guideline is recommended by the Cochrane collaboration for the quality assessment of diagnostic accuracy studies included in a systematic review

Synthesis of results

The narrative synthesis was presented for the study findings, with an emphasis on the intervention details (Sensitivity and Specificity, Negative predictive value and Positive predictive value) patient variables (number, age, and gender), sample number (teeth), type of teeth, and pulse oximeter name and manufacturer.), and outcome assessment.

Literature search and study selection

Study search process according to the PRISMA guidelines showed in [Figure 1] The initial online search yielded a total of 53 studies. After the removal of duplicate studies, the remaining 49 studies were screened for title and abstract, and 21studies were obtained. Out of 21 studies, 16 studies were found irrelevant and were excluded.

Full-text articles of the remaining 5 studies were obtained and thoroughly assessed for eligibility criteria by two authors. These studies met the eligibility criteria and were included in the systematic review. [Figure 1]

The general characteristics of the included studies are listed in [Table 2]

Quality of included studies

The results of the quality assessment were evaluated according to Cochrane Tool. Based on Cochran's quality assessment tool, included studies showed good quality assessment [Figure 2]. Low risk of bias was shown in most of the studies [Figure 3].

Discussion

Pulp sensibility tests have limitations, and false responses can occur (3). EPTs are known to be unreliable in immature teeth and in teeth undergoing orthodontic movement (5). Sensibility tests present

inconsistent results for the pulpal diagnosis of traumatized teeth (6)

Data obtained from thermal and electrical tests are dependent on the patient's subjective perception and description of a response to the applied stimulus. The application of a testing stimulus by the operator is dependent on the length of time it is applied, where and how it is placed on the tooth, as well as the physical character of the stimulus (degree of heat, cold, pressure) (7).

It limits the predictive value of a test particularly in the trauma patient where damage to the periodontium and psychological factors interfere with the perception of any stimulus.

Studies examining the applicability of pulse oximetry to vitality testing have been promising (7). A comparison of readings from a custom-made pulse oximeter and conventional vitality tests performed on teeth selected for endodontic treatment revealed that the pulse oximeter was more reliable than the EPT, heat, and cold test (8)

To compensate limitations of sensibility tests, some medical equipment such as Pulse oximetry and flowmetry were inserted, because of the accuracy of the diagnosis, these are known as methods of pulpal vitality testing.

Several authors have investigated the accuracy of pulp vitality tests in endodontic diagnosis (2,4,3,5) however, this review focused on the pulpal diagnosis of traumatized teeth, and only 5 articles were included. 4studies revealed the sensitivity and specificity values of the tests evaluated. Only 1study presented the results without statistical analyses (9) Therefore, for a low risk of methodological bias to be found, the studies should include patients with traumatized teeth with or without pulp vitality so that the tests can be applied.

Regarding the quality assessment, the items regarding patient selection exhibited a low risk in all studies

To diagnose the lack of vitality, endodontic treatment can be used as a reference standard (14). In 4 studies, the use of a reference standard to confirm the results of the index tests was mentioned only 1 study (9) do not mentioned about reference standard.

To minimize the assessor-related bias, it is expected that the assessors are blinded to the correct diagnosis before applying the tests. 4 studies (2, 9-11) involved three blinded operators. These studies presented a low risk of bias in this domain. Only one study (8) did not mention about blinding procedure.

If sensibility and vitality tests are performed at different times, the pulpal condition may change. Time for sensibility tests differs in involved studies but each tooth was evaluated for 30 sec following which readings obtained on pulse oximeter was recorded.

Four articles studied the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of Pulse oximeter as opposed to other diagnostic methods, and in all of them, Pulse Oximeter showed higher results (2,8,10,11).

The pulp's anatomy and its distance from the sensor are other factors that could influence the reading. Moreover, age plays an important role, resulting in a series of time-dependent morpho-physiological changes in the pulp complex dentine continues its growth, and there could be deposition of mineralized tissue in the pulp and root canals (12)

Study by Gopikrishna et al. (9) demonstrated two things: 1. The oxygen saturation values for human permanent teeth using the customized PODP were in the range of 75 to 85%. 2. The oxygen saturation values for teeth (75– 85%) were lower than for fingers (98%), possibly

because of diffraction of the infrared light by the enamel prisms and dentin.

However, pulse oximetry still has many limitations. To obtain a valid result, both diodes need to be parallel, which becomes a challenge because currently there are no pulse oximeters specifically designed for dentistry, and any minor head movement from the patient (such as swallowing) can destabilize the diodes and alter the results(13) Gopikrishna et al. (2007) (2,9) and Dastmalchi et al. (2012) (8) fabricated their own probes, in which sensors could be held parallel and fit onto the teeth anatomy and concluded that pulse oximetry is reliable, effective, and precise as a diagnostic tool for pulp vitality

The heterogeneity regarding the characteristics of the samples from the studies included in the present review, methodology made performing a quantitative analysis or meta-analysis of the results impracticable. For future studies in the field, the use of a standardized methodology is encouraged, in order to facilitate the quantitative analysis of the evidence as a whole.

Certain factors may act as limitation of the present systematic review. Such as, the variety of results produced by the studies included in the present review may be influenced by a series of factors, namely, The range of sample sizes, teeth studied (which differ in size and shape), participant ages, pulse oximeter brands, and, generally, the methodology used.

However, the qualitative synthesis performed may act as preliminary evidence of the possible application of pulse oximetry as an objective method of pulp vitality testing

Conclusion

The results of this systematic review suggest that pulse oximetry is a reliable and promising tool for the diagnosis of pulp vitality, it still has many limitations that hinder its use in daily dental practice. There is a need to design a specific pulse oximeter to use on teeth.

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Legend Tables and Figures

Table 1: Shows the eligibility criteria for inclusion of the studies in regard to participants, intervention, comparator, and outcomes

Inclusion criteria	Exclusion criteria
Population - Single rooted permanent teeth Intervention - Custom made pulse oximeter Comparator- Other sensibility tests (thermal or electrical) Outcome - Custom made pulse oximeter is reliable method in determining the actual status of pulp in endodontics Study design - Randomize clinical trials and Non randomise clinical trials	Descriptive studies Editorial studies Case reports Case series In vitro studies Literature reviews In vivo studies in animal models

Figure 1: Flow chart of methodology according to (Preferred Reporting Items for Systematic Review and Meta-Analysis) guidelines.

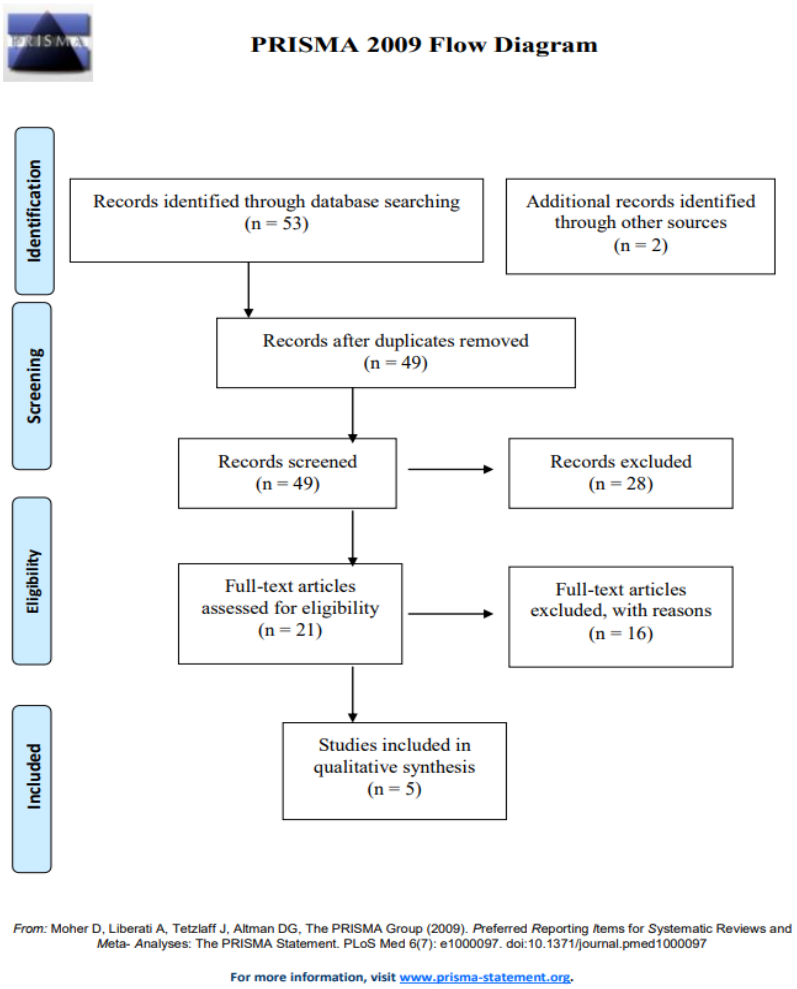

Figure 2: Risk of bias and applicability concerns summary.

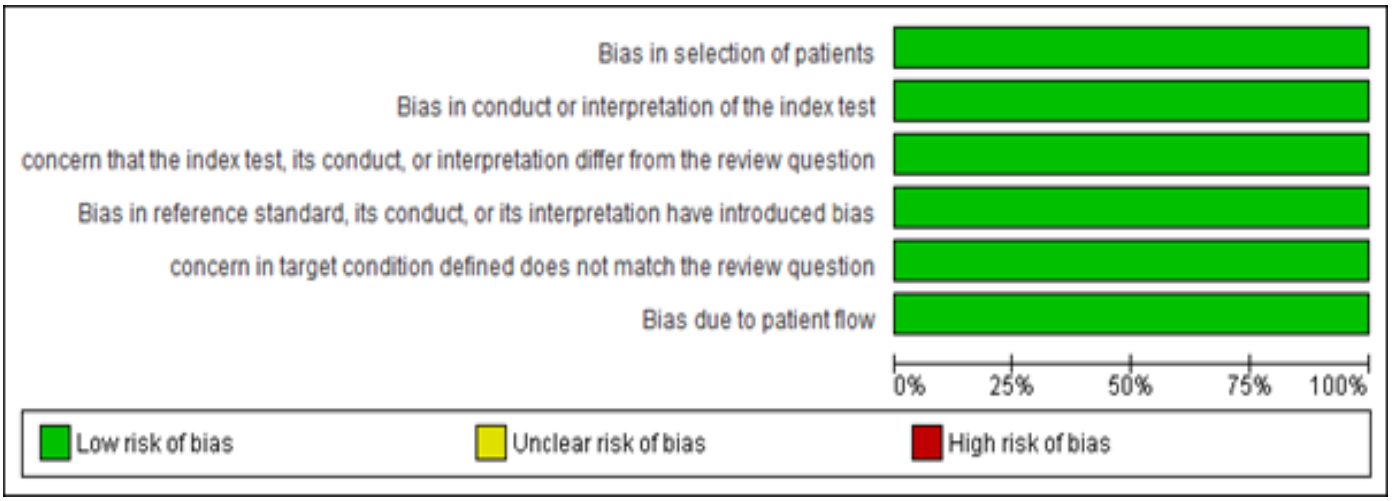

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study.