Validity of Preoperative Clinical Findings to Identify Dental Pulp Status: A National Dental Practice-Based Research Network Study

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Abstract

Introduction: Endodontic diagnostic tests are often used clinically to assess pulp status as a basis for the diagnosis and determination of whether root canal treatment (RCT) is indicated. Response to cold and pain on percussion are 2 common tests, yet their validity in identifying nonvital pulp in regular dental practice has not been reported. **Methods:** We assessed the validity of cold and percussion tests to identify nonvital pulp in teeth requiring RCT in a dental practice setting performed by 46 general dentists and 16 endodontists in the National Dental Practice-Based Research Network. The influence of patient-, tooth-, and dentist-related characteristics was investigated. Observed bleeding from the pulp chamber was the clinical reference. Sensitivity (SN), specificity (SP), overall test accuracy (TA), positive (PPV) and negative (NPV) predictive values, and likelihood and diagnostic odds ratios (LR+, LR−, dORs) were calculated for each single test and the combined cold and percussion tests. **Results:** Seven hundred eight patient teeth were included. Cold test showed high validity to identify a nonvital pulp status (SN = 89%, SP = 80%, TA = 84%, PPV = 81%, NPV = 88%, LR+ = 4.35, LR− = 0.14, dOR = 31.4), whereas pain on percussion had lower validity (SN = 72%, SP = 41%, TA = 56%, PPV = 54%, NPV = 60%, LR+ = 1.22, LR− = 0.69, dOR = 1.78). Combining the 2 tests did not increase validity, whereas preoperative pain, medication intake, patient age and sex, and dentist training level affected test validity significantly. **Conclusions:** In regular dental practice, the cold test exhibits higher validity to discriminate between vital and nonvital pulp than the tooth percussion test. *(J Endod 2016;42:935–942)*

Key Words

Dental pulp necrosis, dental pulp test, diagnostic test validity, endodontics, root canal therapy, sensitivity and specificity

Deriving a correct endodontic diagnosis related to the status of pulp tissue is important in guiding endodontic treatment planning. Determining whether the pulp tissue is vital (ie, blood circulation) or nonvital (ie, necrotic) is a key step in diagnosis because the options for treatment differ. Renewed emphasis on the validity of practical procedures to differentiate between these 2 pulp states is needed because recent research suggests that preserving pulp vitality may be more attainable than previously thought (1, 2).

Studies examining diagnostic test validity are scarce and usually examine selected samples and a small number of subjects. A recent systematic review concluded that there was insufficient evidence to determine the diagnostic accuracy of symptoms, signs, and diagnostic tests (eg, pulp vitality tests and pain provocation) to determine the pulp status and condition in teeth affected by deep caries, trauma, or other types of injury (3). Cold testing, defined as the responsiveness of pulpal sensory nerves to a cold stimulus, has shown fairly high sensitivity (usually >75%), with variable specificity (12%–98%) (4–10). The evidence for cold test validity has recently been rated as insufficient because published studies have several limitations (3). Percussion pain or tenderness is generally interpreted as a sign of apical inflammation. Because this is usually caused by bacterial infection of necrotic pulp tissue, percussion tenderness may indirectly indicate a nonvital pulp. However, percussion tenderness has also been reported in symptom-free vital teeth with deep caries (11) and in symptomatic pulpitis (7), and it is conceivable that other mechanisms could explain this, such as pulpitis-induced sensitization of pulp nociceptors (12). The validity of the percussion test to identify nonvital pulp has seldom been tested in studies designed to reliably assess diagnostic accuracy and is thus largely unknown (3).

The lack of high-quality studies providing knowledge about the validity of diagnostic tests to identify the pulp status is troubling because the decision to provide irreversible treatment is based on the results of these tests (1, 7). To be valuable to the clinician, a test needs to deliver accurate results under normal clinical conditions (13). Studies of diagnostic test accuracy are designed to compare the results of a certain test (ie, the index test) to the "truth" of whether disease is present or not represented by results obtained with a gold standard (ie, the reference standard). Examining validity

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under rigorous research conditions with a limited number of highly trained examiners and a standardized test protocol (14) is important to determine diagnostic accuracy with a high level of evidence; however, the generalizability for use in regular clinical practice where the majority of patients receive their care may be limited. In addition, studies examining the influence of tooth or patient characteristics on validity are lacking.

A pragmatic study investigates the benefit of a procedure in routine clinical practice (15). To address the gaps in knowledge regarding the effectiveness of diagnostic tests used in regular dental practice, we used a pragmatic design, aiming to evaluate the validity of cold and percussion testing to identify pulp status (ie, vital or nonvital) and determine whether the validity was modified by either combined testing or tooth-, patient-, or dentist-related characteristics.

Methods

Brief Overview of the Study

This research was conducted within the National Dental Practice-Based Research Network (16, 17) (http://nationaldentalpbrn.org/). The present report is based on secondary analyses of data originally collected. The original study was designed to prospectively assess outcomes after root canal treatment (RCT), and details of study methods (18) and outcomes (19–22) have been previously reported. In brief, 62 dentists (46 general practitioners and 16 endodontic specialists) from 5 regions (Alabama/Mississippi, Florida/Georgia, Minnesota, Oregon/Washington, and Denmark/Sweden) participated by collecting observational data from endodontic patients in their practices. Before study initiation, patients' informed consent and regional and University of Minnesota ethical review board approval were obtained. Participation was voluntary, and declination to participate did not impact care.

Patient Eligibility and Recruitment

Consecutive eligible patients were recruited by their dentist, and inclusion criteria were age 19–70 years and having a permanent tooth requiring primary RCT (regardless of endodontic diagnosis, symptoms, tooth type, restorative status, or jaw). Exclusion criteria were the following: iatrogenic pulpal exposure (ie, cases of carious pulp exposure were included); previous enrollment in the study (ie, each patient could contribute only 1 tooth); obvious cognitive impairments (such as prior stroke with communication deficits, dementia, or mental disability); inability to read, understand, and complete the questionnaire provided in English (US regions) or Danish/Swedish (Scandinavian region); and anticipated unavailability for the 6-month follow-up (criterion related to the objectives of the prospective study).

Data Collection

Timing. Data collection was obtained via paper questionnaires in the dental office. Questionnaires were completed by patients before treatment and placed in a sealed envelope to conceal their responses from the dentist and staff. Dentists completed 2 separate questionnaires, 1 before treatment (including the results of the index tests) and 1 immediately after treatment (including the result of the reference test). The time from completion of the preoperative questionnaire to making the intraoperative observation was not standardized but is estimated to between 10 and 60 minutes based on routine practice. Data collection forms are available online (http://nationaldentalpbrn.org/peer-reviewed-publications.php).

Characterization. Patient-reported data included demographic information, history of index tooth pain including medications taken, the presence of chronic body pain, fear about the dental procedure (4 items, not at all to very much), and optimism regarding the result of the procedure (4 items, very good to poor expectation) (Table 1).

Reference Standard

The observation of bleeding pulp tissue in the pulp chamber upon initiation of the RCT was interpreted as vital pulp (ie, normal pulp, reversible pulpitis, or irreversible pulpitis), whereas the definition of the disease state was the absence of bleeding in the pulp chamber, interpreted as nonvital pulp (ie, partially or totally necrotic pulp). All included teeth were assessed using the reference standard. To assess the reference standard, a more stringent standard was also applied and the results compared to evaluate for the presence of systematic differences. This more stringent standard defined vital pulp as the presence of bleeding combined with the absence of a radiolucency and defined nonvital pulp as the absence of bleeding combined with the presence of a radiolucency. The presence/absence of a periapical radiolucency was determined by the dentist treating the patient and noted in the dentist's preoperative questionnaire.

Diagnostic (Index) Tests

We assessed 2 clinical diagnostic tests that are commonly used in practice: nonresponse to cold testing and pain on tooth percussion; the tests were applied regardless of the reason for RCT (Fig. 1). Consistent with regular clinical practice and pragmatic studies, dentists did not receive specific instructions on how to perform or interpret the tests. The order of applying the 2 diagnostic tests was not standardized, but both tests were interpreted before treatment was initiated and the pulp was visually inspected.

Measures of Validity

Sensitivity (SN), specificity (SP), overall test accuracy (TA, the proportion of correctly identified pulp states for each test), and positive (PPV) and negative (NPV) predictive values assessed the validity of tests to identify nonvital pulp. To further evaluate the clinical usefulness of the 2 tests, the positive (LR+) and negative (LR−) likelihood ratios and diagnostic odds ratios (dORs) were calculated for the 2 tests separately and for the combination of tests (13).

Subgroup Assessment

The influence of patient-, tooth-, and dentist-related characteristics on the measures of validity was also analyzed. Nonbinary variables were dichotomized as follows: age: <50 years versus ≥50 years; socioeconomic status: yearly household income <$50,000 versus ≥$50,000; race/ethnicity: white non-Hispanic/Latino versus Other; tooth type: posterior (premolar or molar) versus anterior (incisor or canine); fearfulness of dental appointment: fearful (very much, quite a lot, or a little) versus not fearful; and expectations of RCT outcome: fair to good versus very good.

Statistical Procedures

Descriptive statistics (means, standard deviations, frequencies, and proportions) were used to examine patient characteristics. The Pearson chi-square test analyzed differences for categoric variables, and the Student *t* test was used for continuous variables. Statistical significance was assessed at $P \leq .05$. SN and SP with 95% confidence intervals (CIs) were computed overall and for subgroups. Significant differences in SN and SP between groups were defined as nonoverlapping 95% CIs. For the total sample, 95% CIs were also computed for