

How Helpful Are Diagnostic Tests For Pulpal Conditions?

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Introduction

The assessment of pulp vitality is a crucial diagnostic procedure in the practice of dentistry (Ref 1). Reliability of diagnostic tests directly affects treatment success, decisions to initiate more aggressive clinical interventions, and ability to make informed prognosis about the course of the disease (Ref 2). Pulp testing is often referred to as 'vitality' testing. In fact, a moribund pulp may still give a positive reaction to one of the following tests as the nervous tissue may still function in extreme states of disease. It is also possible in a multi-rooted tooth for one root canal to be diseased, while others still capable of giving a positive response.

Pulp testers should only be used to assess vital or non-vital pulps; they do not quantify disease, nor do they measure health and should not be used to judge the degree of pulpal disease (Ref 3). Several devices and techniques enable the clinician to determine if a tooth is vital or non-vital (Ref 4). Commonly used diagnostic pulp tests in general practice include electric pulp testing and cold testing (Ref 5).

Tests currently available:

- Electric Pulp Testing (EPT)
- Heat/Cold tests- heated guttapercha, ice, carbon dioxide snow (Odontotest).
- Blood flow measuring methods- Laser Doppler flowmetry, Transmitted laser light Tooth surface temperature measuring.
- Cavity test.

Thermal and electrical pulp testing rely on stimulation of nerve fibers and do not give a direct indication of the state of the vascular supply which would more accurately indicate the degree of pulp vitality (Ref 6). These testing methods have the potential to produce an unpleasant and

ABSTRACT

Background:

The purpose of this review was to evaluate the efficacy of various diagnostic tests for pulpal conditions and the reliability of these tests in assessing pulp vitality.

Methods:

Systematic review of available literature, exclusively the human studies. Only seven studies met the required criteria and were included.

Gold Standards:

Histology, Observation of bleeding upon pulp exposure, and endodontically treated teeth.

Conclusion:

Cold test and EPT were found to be more reliable than heat test. Specificity of cold and EPT is higher than their sensitivity. Among different types of cold test, Co2 ice and refrigerant spray were the most accurate ones while ethyl chloride and ice water had the least reliability. Laser Doppler flowmetry and pulse oximetry showed high level of accuracy, which could be valuable specifically in children with traumatized teeth, however, further clinical studies are still required before they can be used regularly in daily practice.

Key Words:

Pulp test, Diagnostic test, Vitality Test

occasionally painful sensation and inaccurate results. In addition they are subjective tests which depend on the patient's perceived response to a stimulus as well as the dentist's interpretation of that response (Ehrman 1977).

Material and Methods

A systematic review of literature was done to obtain potentially relevant articles related to our point of interest.

Search Strategy

In order to identify, select and critically appraise relevant studies, a literature review was conducted using online search engines including Ovid MEDLINE, PubMed and Cochrane Library database. Furthermore, the related references from the following endodontic textbooks were reviewed to identify any additional articles:

- 1) Pathways of the pulp. Cohen S, Hargreaves K.M. 9th ed. 2006, Elsevier Mosby.
- 2) Seltzer and Bender's dental pulp. Hargreaves K.M., Goodis M.E., Quintessence Pub. Co.2007.
- 3) Principles and practice of endodontics. Walton R.E., Torabinejad M., 3rd ed.2002, Saunders.

Members of the Endodontic department at the Faculty of Dentistry, University of Toronto were also consulted for this purpose. By using following keywords: "pulp test", and "vitality test", 772 articles were retrieved, among which, 3 articles were excluded as duplicates, thus 769 articles remained for next stage of systematic review. Limiting the search results to English language articles, dated from January 1974, in vivo human studies narrowed the number of articles to 400 from which 255 were rejected at title stage. Out of 145 remaining studies, 80 more were excluded following reading the abstracts. Finally, 65 articles were obtained and accepted to be appraised based on the inclusion criteria.

Review of Evidence	
Number of articles	400
Articles rejected at title stage	255
Articles rejected at abstract stage	80
Articles rejected at first reading	58
Included Articles	7

Determination of Relevance

65 articles were read and reviewed to determine relevance. These were independently scored by two group members and 58 were rejected after first reading. (A list of excluded articles and reasons for that can be found in Appendix II).

To be deemed relevant to our studies, the article had to meet the following criteria:

- In vivo human study
- Strong study design such as meta analysis, systematic review, clinical trial or case control studies. The articles that were case reports, reviews, surveys, and commentaries were rejected.
- studies on permanent teeth
- studies tested against a valid gold standard

Definition of Gold Standards used

- 1. Histology:** By far the most reliable way of determining pulpal status through examining the presence of regular layers of odontoblasts, presence of red blood cells within the vessels and/or staining of the cells in the body of the pulp. The tooth must be extracted and fixed in formalin 10% immediately after the diagnostic test is done.
- 2. Observation of bleeding upon entering the pulp chamber during root-canal treatment:** Presence of bleeding shows the blood flow of the pulp tissue is functioning which is the sign of vitality. Pulp nerves may be damaged or underdeveloped and as a result do not respond to external stimulus.
- 3. Endodontically treated teeth:** It has the lowest value as a control for a diagnostic test . It is more practical in evaluating the True Negative and False Positive responses (Specificity) rather than Sensitivity of a diagnostic test. Presence of accessory canals (although rare in asymptomatic teeth with single canal) can affect its reliability.

Validity Instrument

Seven articles which met all inclusion criteria were used in the final review and were scored independently by two members of the research group using “The Checklist for Assessing a Diagnostic or predictive test”, (Appendix III - Checklist). In cases of scoring discrepancy, the research group met and re-evaluated the checklist until a final score was established. The seven articles that remained were used to construct a table of evidence to show the relevant findings in a concise manner (Appendix I). The highest attainable score was 8/10.

Statistical Sensitivity and Specificity were then determined in the available clinical trials.

Results

The results of the seven included studies have been summarized in Tables (See Appendix I). When different diagnostic tests are compared with a common control (Gold Standard), their accuracy and effectiveness can be evaluated against each other.

Fig. 1 shows a comparison between cold test, EPT, heat test and Laser Doppler Flowmetry (LDF), weighed against “observation of bleeding upon pulp exposure” as the gold standard. It can be seen that cold test and LDF have the highest accuracy while heat test is the one with the lowest values. However, when it comes to sensitivity, it is the electric pulp test that has the lowest results among all four.

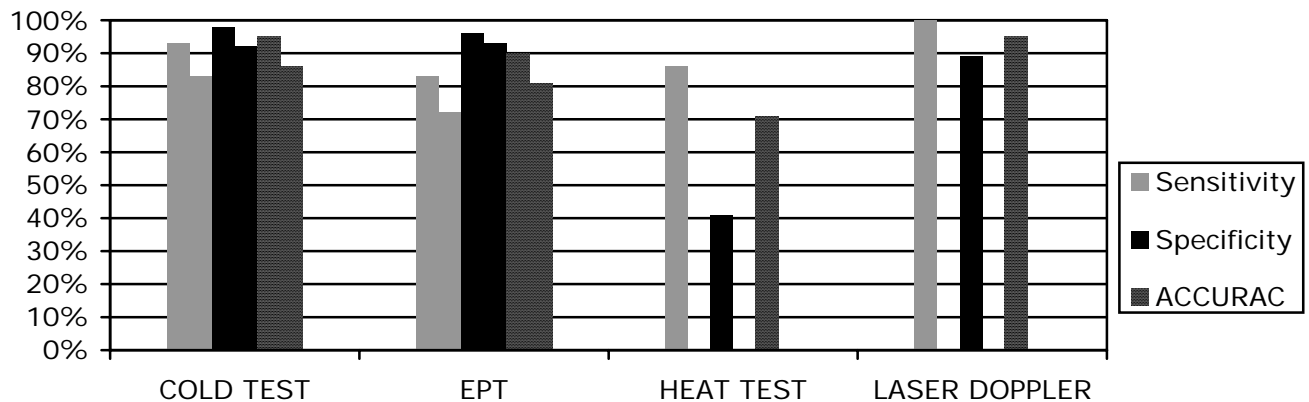


Figure 1- Four different types of Pulp Tests weighed against “Observation of Bleeding upon pulp exposure”

In Fig-2 five different methods of cold tests are evaluated against a gold standard of “teeth with previous RCT”. Findings show that ethyl chloride and ice water are the least reliable types of cold test among all five while non-CFC refrigerant, Co2 Ice and dichlorodifluormethane (DDM) are almost equally effective.

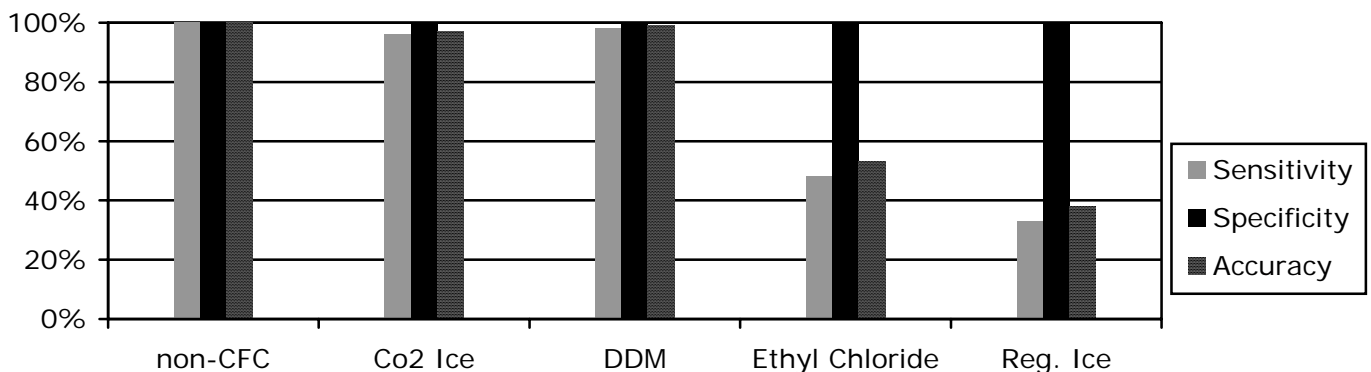


Figure 2- Five different types of cold test evaluated against “teeth with previous RCT”

Fig-3 shows comparison of Electric pulp test results between adults and children when evaluated against the gold standard of "teeth with previous RCT". As it can be seen, the accuracy and sensitivity of EPT is lower in children compared to adults.

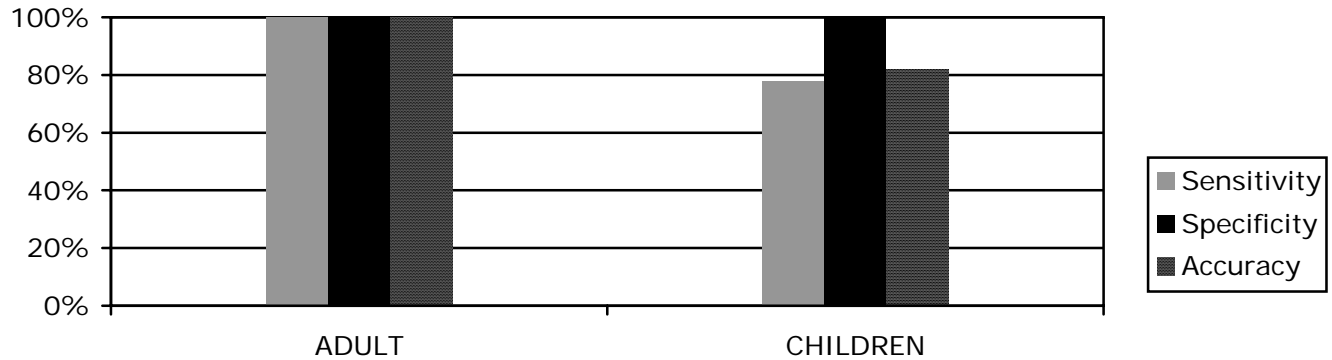


Figure 3- Comparison of Adults and Children re: reliability of electric pulp test.

Fig-4 shows that Transmitted Laser Light can be as effective as pulse oximetry when used only on the anterior teeth. However, it 's sensitivity and accuracy drops when premolars are also included.

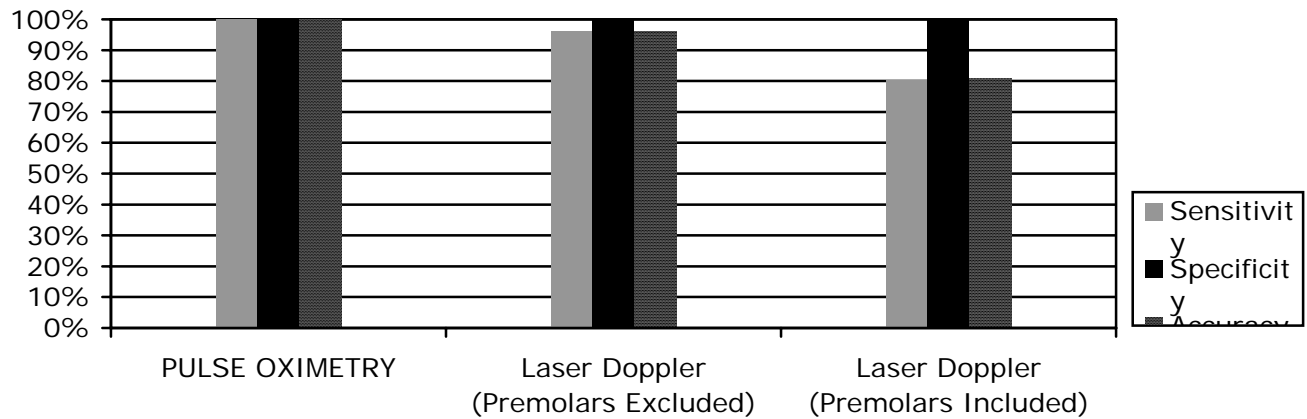


Figure 4- comparison of pulse oximetry and transmitted laser light. The gold standard is "teeth with previous RCT".

Discussion

An assessment of pulp vitality is not as easy a task to perform as it may seem with its relative simplicity. A critical review of present literature has further added to the question, "Is there any single test that we can rely upon with full confidence?" Unfortunately, the answer is "no".

In order to reach maximum diagnostic evaluation, several combinations were created: EPT, Cold Tests, Heat tests, Laser Doppler, Transmitted Laser Light, Pulse Oximetry and Crown temp. All of them are not of equal diagnostic value. Although current evidence suggests that the use of Cold tests in adults (Schnettler 1999) and Laser Doppler in children and traumatized teeth (Evans 1999) have been found to be near acceptable levels of accuracy, these tests need to be applied with critical judgment. This judgment will be based on theoretical knowledge and a combination of the patient's subjective and objective symptoms and radiographic evaluation.

The controversy in determining the effectiveness of different tests should be evaluated with larger study designs comparing their results with histological analysis. Although histology as a gold standard is not practical and applicable in clinical conditions, many authors (Fulling, Andreason 1976 and Matthews 1974) have accepted it as a gold standard for comparison to all other tests keeping in mind its lack of ambiguity. Some other methods like crown temperature are more difficult to perform and unreliable (Stoops, Scott 1976) and are included in our report only for completeness.

The results analyzed from our evidence-based table support the reliability of cold test over EPT (Kamburoglu et al 2005, Petersson et al 1999)(Fig.1). Among different types of cold test, CO₂ Snow and DDM found to be more accurate than ethyl chloride and ice in determining true positive and true negative states (Fuss et al 1986)(Fig.2). However study by Schnettler 1991 demonstrated cold test and EPT to have both sensitivity and specificity ratios of 1. The difference between their findings and the previously mentioned studies can be related to the fact that the gold standard of determining the accuracy was not similar among those studies. Also, Schnettler et al (1991) used a very small number of previously root canal treated teeth as their control group. On similar basis, study by Fuss et al (1986) used previously RCT treated teeth as their gold standard which produced the high sensitivity and specificity ratios of 1 for EPT among adult group. (Fig. 3)

Among other methods of testing pulpal vitality, Laser Doppler Flowmetry (LDF) is an objective, noninvasive, non painful and acceptable test to young children (Fratkin et al. 1999). A study by Evans et al (1999) showed highest levels of sensitivity, specificity for LDF similar to cold test and EPT (Fig.1). However, Sasano et al (2005) demonstrated that LDF results were less accurate in determining pulpal status in premolar teeth versus the anteriors. This can be due to different thickness of enamel and dentin which, in premolars, makes it difficult for the laser beam to pass through (Fig.4). Based on significant similarity between pulse and Oxygen Saturation in finger and vital tooth, pulse Oximetry has been shown to be as accurate as cold test and electric tests in determining tooth vitality (Schnettler et al 1991). However, we did not find any other evidence to support their findings.

Conclusion

- The research findings show that there is no universal test for every patient and situation due to the fact that teeth and condition of the pulp show great individuality depending on factors like tooth anatomy, morphology, histology of specific condition and general health of the patient.

- Even when functioning at the greatest possible level of precision every test may misclassify a certain percentage of patients.
- The results from our evidence-based table support the reliability of Cold test over Electric Pulp test.
- The specificity of Electric Pulp test and Cold test is higher than their sensitivity.
- Although these studies indicate high accuracy for Laser Doppler Flowmetry and Pulse Oximetry, further studies to determine the reliability of these tests are needed.
- Larger study designs with comparison against common gold standard of histology can help clinicians in choosing the right test for determining pulp status before any further recommendations can be made.

Acknowledgements

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Appendix I – Summary of Reviewed Studies

Author	Study Design	Sample Size	Diagnostic Test	Compared to Gold Standard	Sensitivity	Specificity	PPV	NPV	Accuracy	Critical Appraisal Comments	Conclusion	Evidence Level
Matthews et al. 1974	CCT	- 30 teeth to be extracted	- Electric pulp tester with no current control	Yes Histology	1.00	0.00	0.87	0.87	0.00	- The order of using the tests was determined randomly. - Small proportion of non-vital teeth - No blind evaluation	-There was no correlation between the thresholds of the vital teeth & the pathological state of their pulp - Electric pulp testers with no current control have no value in determining the vitality of a tooth due to false positive responses - False negative responses can be the result of neural death while other pulpal cells survived	8/10
			- Electric pulp tester with constant current stimulator		0.62	1.00	1.00	0.28	0.67			
Kamburoglu et al. 2005 Turkey	CCT	- 142 teeth of 97 patients - 93 teeth needed RCT - 49 intact teeth	- Cold test using Coolan (non-CFC) for 15s.	Yes (Cavity test + observation of bleeding upon pulp exposure)	.93	0.98	0.97	0.94	0.95	-No blind evaluation - Specificity & sensitivity calculated - No random assignment - True status of 49 intact teeth unclear	1. Based on the sensitivity, specificity, positive predictive value, negative predictive value and accuracy rate calculations the cold test is more reliable than the electric pulp test. 2. Specificity values were higher than the sensitivity values; the ability of the tests to identify teeth free from disease (vital, disease negative) is higher than the ability to identify diseased teeth 3. All teeth that showed pulpal bleeding on the opening of pulp chambers were sensitive to removal of caries without anesthesia.	8/10
			- Electric pulp test using Digitest (twice then report the Avg)		0.83	0.96	0.94	0.87	0.90			
			- Continuity of Lamina Dura		1.00	1.00	1.00	1.00	1.00			
			- PDL widening		1.00	0.80	N/A	N/A	N/A			
Petersson et al. 1999	CCT	75 teeth - 59 Teeth in need of	- Cold test using Ethyl Chloride	Yes (observation of bleeding upon pulp	0.83	0.92	0.89	0.90	0.86	-No blind evaluation - Specificity & sensitivity calculated - No random assignment - True status of 16 intact teeth unclear (They were judged as vital)	1. Based on the sensitivity, specificity, positive predictive value, negative predictive value and accuracy rate calculations the cold test is more	8/10

		RCT - 16 intact teeth	- Electric pulp test using Analytic Technology Pulp Tester	exposure)	0.72	0.9 3	0.8 8	0.8 4	0.8 1		reliable than the electric pulp test & heat test. 2. For cold test and EPT specificity values were higher than the sensitivity values; the ability of the tests to identify teeth free from disease is higher than the ability to identify diseased teeth 3. For heat test sensitivity value was higher than the specificity value; the ability of the tests to identify diseased teeth is higher than the ability to identify disease free teeth	
			- Heat test using hot gutta- percha		0.86	0.4 1	0.4 8	0.8 3	0.7 1			
Schnettler et al. 1991 USA	CCT	- 49 permanent maxillary central incisors - 44 unknown vitality - 5 with previous RCT	-Electric pulp test	Yes Teeth with previous RCT	1.00	1.0 0	1.0 0	1.0 0	1.0 0	- No blind evaluation - No statistic data was provided - Small proportion of diseased teeth (with previous RCT) - No information was given Re: condition of teeth * Due to unknown vitality status of 44 teeth, the true+ and false- results (sensitivity) can not be evaluates accurately	- There is significant similarity between pulse and Oxygen Saturation in finger and vital tooth - Pulse Oximetry can be as accurate as cold test and electric tests in determining tooth vitality	7/1 0
			-Cold test (Frigident)		1.00	1.0 0	1.0 0	1.0 0	1.0 0			
			- Pulpal pulse oximetry with control on finger		1.00	1.0 0	1.0 0	1.0 0	1.0 0			
Evans et al. 1999	CCT	67 Non vital Ant. teeth 55 Pt's. 77 vital ant. teeth [control gp.]	- Laser Doppler Flowmetry	Yes (observati on of bleeding upon pulp exposure)	1.00	0.8 9	0.9 1	1.0 0	0.9 5	-No blind evaluation -Reduced bias, not based on patient's subjective description of symptoms - No random assignment	- Analysis of LDF recordings taken from all teeth allowed diagnostic criteria to be developed which have <u>sensitivity</u> & <u>specificity of 1</u> in between vital & non vital where at least coronal tissue was necrotic - LDF-potential test in management of traumatized ant. Teeth	7/1 0
Fuss et al. 1986 USA	CCT	24 Subjects 11male, 13 female - 96 clinically sound PM's - 10 Teeth	-Co2 Snow	Yes Teeth with previous RCT	0.96	1.0 0	1.0 0	0.7 6	0.9 7	- No random assignment - Blind control- pt. didn't know which agent applied - Specific criteria for exclusion - Type of teeth not specified for control gp. [endodontically treated teeth]	DDM, Co2 Snow, EPT almost equally reliable [more than Ethyl chloride or Ice] when used to test vitality of teeth in adult pt's. However in young DDM, Co2 Snow found more reliable than EPT	6/1 0
			-DDM		0.98	1.0 0	1.0 0	0.9 0	0.9 9			

		with previous RCT	-EPT (Adult Group)		1.00	1.00	1.00	1.00	1.00	- No significant differences found between males & females in % of +ve responses to any of vitality testing agents		
			-EPT (Younger Group)		0.78	1.00	1.00	0.50	0.82			
			-Ethylchloride		0.48	1.00	1.00	0.16	0.53			
			-Regular Ice		0.33	1.00	1.00	0.13	0.38			
Sasano et al. 2005 Japan	CCT	- 15 subjects 22-28 years old - 61 vital teeth with no restoration - 5 endo treated teeth filled with Gutta Percha.	Transmitted laser light (Premolars included)*	Yes Teeth with previous RCT	0.80	1.00	1.00	0.29	0.81	- No random assignment - No blind evaluation - Specificity and Sensitivity Calculated. - No information on strength of laser power signal used. - True status of 61 vital teeth unknown. * Since transmitted laser light was unable to detect pulpal Blood Flow in first premolar so sensitivity and specificity were calculated both with and without including Premolar teeth.	Based on the observations from this experiment, transmitted laser light at increased power should be useful for monitoring pulpal Blood Flow (BF) and for the assessment of tooth pulp vitality both because the BF signals do not include flow of non pulpal origin and because output signals and response to BF changes can clearly be monitored from thick anterior teeth. However transmitted laser light was unable to detect pulpal BF in first premolar. It was found as the result of this experiment that by increasing the laser power on the transmitted laser-light gave clearer BF signals from vital teeth. None of the non vital teeth displayed any blood flow signal.	6/10
			Transmitted laser light (Premolars excluded)*		0.96	1.00	1.00	0.71	0.96			

Appendix II – Excluded Articles

EXLUDED ARTICLES	REASON FOR EXCLUSION
Nam et al, 2005	Minimizing pain and stress by reducing excessive pulp stimulation.
Nam et al, 2005	To measure excessive electrical stimulus time during pulp testing
Milleret al, 2004	Test was done on extracted teeth.
Carrotte, 2004	Discussion of treatment plan
Maupome et al, 2004	Clinical and visual examination, apex locators, vitality testers and colour shade guides in light of the tools described without studies
Smith et al, 2004	In-vitro study
Robinson, 1987	Studies on auto transplanted teeth.
Abdel Wahab et al, 1987	Comparison of slow and rapid increasing current during stimulation of human teeth.
Dreven et al. 1987	By title
Fanibund, 1986	Clinical evaluation only.
Hill, 1986	Only one article found, not enough to compare to make the recommendations.
Emshoff et al. 2004	Inadequacy of control group.
Kress et al. 2004	Not enough evidence.
Winzap-Kalin et al. 2005	*Only abstract, German article not available
Leffingwell et al. 2004	Distinguish dentin sensitive teeth via cold test
Hejne 2003	Influence of occlusal interference on pulp vitality threshold, using only one type of electric pulp test
Jones et al. 1994	Psychological variables affecting electric pulp test
Ramsay et al. 1991	Was not compared against a validated test (or Gold Standard)
Schulz et al. 1991	Clinical recommendations
Schmitt et al. 1991	Animal study
Butel et al. 1991	Danger of cross infection while performing diagnostic tests
Rosenberg 1991	Not a study
Rohdewald et al 1990	Evaluation of algometric parameters via pulp tests
Rowe et al. 1990	Not a study
Andreasen et al. 1990	Evaluation of pulp healing after autotransplantation
Edwards et al. 1989	Effectiveness of anesthesia evaluated by electric pulp tester
Cailleateau et al. 1989	Not a study
Bender et al. 1989	Optimum placement site for electric pulp test electrode
Bachmann et al. 1976	Evaluation of crack development following 2 types of cold test
Michaelson et al. 1975	Evaluation of interface media in electric pulp tester
West 2004	Expert opinion
Akpinar 2004	Not relevant- how to use the Doppler test, effect of the gingival
Berhman 2003	Limited in time. Treatment is considered only.
Ruddle	Expert opinion. No control/study groups.
Roeykens 2002	Case-report
Kardelis 2002	Teeth are OK- not mentioning “pulp conditions”
Cooley et al.1978	Expert opinion
Klein 1978	Tested on children by EPT
Ehrmann 1977	Expert opinion
Stark 1977	Description of a new method. Not conclusive.

Fulling 1976	On children EPT. 1 examiner only. No control group.
Hietanen 1976	Comparison between testers.
Stoops 1976	Unreliable method. No randomization
Cave 2001	Low level of evidence, no ideal control group
Naikajima 1997	Very few patients. Depends on the position of probe.
Sasano et al, 1997	No comparison between vital & non vital teeth
Myers , 1998	In Vitro study
Eli et al, 1997	Not directly focused on clinical issue in question
Dummer et al, 1986	Not addressing the clinical issue in question, no control group present
Cooley et al, 1984	No control group Present. No evaluation against gold standard
Hyman et al, 1984	Review article
Fanibunda, 1985	In-vitro Study
Jones. 1999	Not addressing the clinical issue in question
Hall et al. 1998	Not addressing the clinical issue in question
Peters et al, 1986	Not addressing the clinical issue in question
Jacobson, 1984	Not addressing the clinical issue in question
Penna et al 1995	Shows method to use EPT
Noblett et al, 1996	In vitro study only
Harris, 1982	Case report only
Cooley 1980	Half article on laboratory test half on only 2 teeth
Antel et al, 1979	Inconclusive result
Guerra et al, 1993	Technique of using barrier
Holan 1993	Emphasis on weaving gloves or not with EPT
Ingolfsson et al, 1994	Emphasis of probe diameter of LDF, also small sample size
Pantera et al, 1993	Use of EPT after dichlorodifluoromethane
Johnsen et al, 1979	Children not reliable for vitalometer
Ingolfsson et al, 1994	More emphasis on probe diameter and small sample size
Aanderud-Larsen et al, 1995	No sensitivity, specificity, no comparison with gold standard
Peters et al, 1994	No sensitivity, specificity, no comparison with gold standard
Augsburger et al, 1981	In vitro only
Tool et al, 2000	Investigation of Language during pulp testing on children
Kells et al, 2000	Thermo graphic Imaging - Small sample, no gold standard
Radhakrishnan et al, 2002	EPT in children
Roebuck et al, 2000	Test performed on children
Matsumoto et al, 2000	No study no population
Goho et al, 1999	Pulse oximetry in traumatized teeth
Anderson et al, 1988	Influence of barrier on EPT, small population
Rickoff et al, 1988	EPT on extracted teeth
Olgart et al, 1988	LDF on luxated teeth
Booth et al, 1988	Small sample, no control
Brandt et al, 1988	Electrometric sensitivity testing on centrals on kids
Kleier DJ et al, 1982	Not addressing the clinical issue in question
Chambers IG, 1982	Review of articles (expert opinion)
Peter DD et al, 1983	In vitro study (extracted teeth surfaces were examined)
Rana AS and Gohil KS, 1983	Unable to locate the article,
Foreman PC, 1983	Based on colour differences under UV light
Lado EA, 1983	Not a study, general info given re: major reasons for variation of EPT readings on vital teeth,
Santopolo J, 1984	Irrelevant article (for obturation)

Asfour et al, 1996	Study on deciduous teeth with EPT and ethyl chloride
Falcone et al, 1996	Irrelevant article re: cardiology and pulp tests
Mercer C, 1996	Not addressing the clinical issue in question
Odor et al, 1996	Not addressing the clinical issue in question
Tokita et al, 1996	Case report
Kahan et al, 1996	Evaluation of customized probe for pulse oximeter
Oikarinen et al, 1996	Wasn't evaluated against a gold standard
Daskalov et al, 1997	Unable to locate the article.
Musselwhite et al, 1997	Evaluation of effects of local anesthetics on pulpal blood flow.
Oikarinen et al, 1997	In-vitro study
Fratkin et al, 1999	Low evidence level
Jones et al, 2002	Low evidence level
Ingolfsson et al, 1993	Study deals with variation in method of conducting the test not the test itself.
Robert F Devin et al.	Explanation on how the test is done.
Dean A Kolbinson et al, 1988	Explains effect of wearing or not wearing gloves when doing the EPT. No control group.
R.W.Mills	In vitro study on extracted teeth.
Roni Nissan et al, 1992	In vitro study on human and dog teeth.
Abdel- Wahab et al, 1985	Deals with effect of changing ice stick diameter rather than efficacy of test. No control group.
D.C.M Kennedy, M.C.Kiely, P.J.Keating From Journal of Irish Dental Association vol 33 No 2,3 ,4	Study mainly focuses on interexaminer and intraexaminer reproducibility .

Appendix III – Checklist

University of Toronto
Community Dentistry

Checklist for Assessing Diagnostic or Predictive Tests

Citation: _____

- a) Was the study ethical?
- b) Is the test clearly described (including the cut-off values)?
- c) Was the test evaluated against a valid gold standard?
- d) Were the test results and disease status determined independently?
- e) Was the test evaluated using patients with a range of severity of disease?
- f) Was the test evaluated among patients with diseases that might be confused with, or are closely related to, the disease of interest?
- g) Is the test's performance reported using sensitivity/specificity, likelihood ratios
- h) Is the effect of moving the cut-off reported, or is the ROC curve provided?
- i) Does this test give better results than the current or standard test?
- j) Is the test likely to be acceptable to patients?

Adapted from: Fletcher, Fletcher and Wagner. Clinical epidemiology - the essentials. 3rd ed. 1996, and Sackett et al. Evidence-based medicine: how to practice and teach EBM. 1997