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Effectiveness of Various Diagnostic Tests in Diagnosing Dentinal Hypersensitivity-A Systematic Review

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Abstract:*Dentinal hypersensitivity has been defined as a short, sharp pain arising from exposed dentin as a result of various stimuli such as heat, cold, chemical or osmotic, that cannot be ascribed to any other pathology. Although dentin hypersensitivity is a common clinical condition and is generally reported by the patient after experiencing a sharp, short pain caused by one of several different external stimuli, it is often inadequately understood. The purpose of this review is to discuss different available diagnostic approaches and assessment methods used, in order to suggest a basis to diagnose, monitor, and measure these challenging painful conditions related to dentin hypersensitivity.*

Objective: *To evaluate the effectiveness of tactile test in diagnosing dentinal hypersensitivity compared to other diagnostic tests.*

Conclusion*: Tactile test with Yeaple probe shows more percentage reduction in dentin hypersensitvity when compared to other diagnostic tests. Tactile testing is recommended as a better tool in diagnosing dentin hypersensitivity and in comparing efficacy of various agents in treatment of dentin hypersensitivity.*

I. Introduction

Dentinal hypersensitivity has been defined as a short, sharp pain arising from exposed dentine as a result of various stimuli such as heat, cold, chemical or osmotic, that cannot be ascribed to any other pathology(1). Although dentin hypersensitivity is a common clinical condition and is generally reported by the patient after experiencing a sharp, short pain caused by one of several different external stimuli, it is often inadequately understood. The purpose of this review is to discuss different available diagnostic approaches and assessment methods used, in order to suggest a basis to diagnose, monitor, and measure these challenging painful conditions related to dentin hypersensitivity.

Objective

To evaluate the effectiveness of tactile test in diagnosing dentinal hypersensitivity compared to other diagnostic tests.

Search Strategy

The following databases were searched:PubMed Central (until August 2013), Medline and Cochrane Database of Systematic Reviews. Bibliographies of clinical studies and reviews identified in the electronic search were analysed for studies published outside the electronically searched journals.

Selection Criteria

Randomized controlled trials in which the tactile stimulation is used for testing dentinal hypersensitivityalong with other diagnostic aids.

II. Main Results

This review included 41 randomized controlled trials in which effectiveness of tactile was compared with other diagnostic tests in evaluation of dentin hypersensitivity. Clinical parameters comparing tactile test with other diagnostic tests (Air blast test, Cold test, Thermal test, Subjective assessment/VAS) were checked as primary outcomes. Tactile testing, especially with Yeaple probe, performs better than other diagnostic tests in evaluation of dentin hypersensitivity.

Author's conclusion

Tactile test with Yeaple probe shows more percentage reduction in dentin hypersensitvity when compared to other diagnostic tests. Tactile testing is recommended as a better tool in diagnosing dentin hypersensitivity and in comparing efficacy of various agents in treatment of dentin hypersensitivity.

III. Background

Dentin hypersensitivity is characterized by distinctive short, sharp pain arising from exposed dentin in response to various external stimuli that are typically thermal, evaporative, tactile, electrical, osmotic, or chemical, which cannot be ascribed to any other form of dental pathology, defect, or disease.

The most frequently experienced pain from dentin hypersensitivity is characterized by a rapid onset, sharp burst of pain of short duration on application of stimuli. Since several oral conditions may cause dental pain, the diagnosis of dentin hypersensitivity can be very difficult (2, 3, 4). Although there are numerous studies related to dentin hypersensitivity, a relatively high number of dental professionals are still confused about the diagnosisof hypersensitivity (4, 5). Time is needed to make a correct diagnosis, because dentin hypersensitivity is always a diagnosis of exclusion; it could only definitely be confirmed after all possible other conditions have been diagnostically eliminated.

Traditionally, dentinal hypersensitivity has been evaluated subjectively, based on the patient response elicited on applying a triggering stimulus. Such stimuli can be classified into four categories: mechanical, chemical, electrical and thermal, though evaluation and interpretation of the pain produced by them is more complicated to standardize – thus explaining the difficulty of contrasting treatments.

Mechanical or tactile stimuliinclude scratching of the dentinal surface with a sharp-tipped probe; mechanical pressure stimulators; or use of the so-called Yeaple probe.

These stimulators are applied perpendicular to the surface of the tooth, and the pressure in grams is gradually increased until the pain threshold is reached. The Williams probe (Manual probe) is a straight probe, 13 millimeters in length and one millimeterin diameter, with demarcation lines at 1, 2, 3, 5, 7, 8, 9and 10 millimeters, and is still widely used in clinical practicetoday.In the case of the Yeaple probe, force variation is controlled by an electromagnetic device.

Other probes which can be used to evaluate hypersensitivity is the University of Carolina true Pressure Sensitive probe (UNC-TPS). This probe was designed to obtain accurate and reliable measurements utilizing the same 20 grams of force every time it's used.

In air blast test, an air current from the dental chair is applied for one second perpendicular to the surface of the tooth. Application of the air current for more than one second leads to temperature variations. Due to the difficulty of localizing the sensitive dentine with the air blast technique, the procedure is usually used for the screening and initial selection of teeth and subjects destined for study.

In Cold water stimulation, water at a temperature of 7ºC is used for the identification of dentinal hypersensitivity and for minimizing the incidence of false-positive results.

Subjectiveexperience of pain is quantified with help of different scales such as Verbal Rating Scale (VRS), Visual Analog Scale (VAS).

The correct attribution of dental pain to dentin hypersensitivity is essential for dentists to implement appropriate treatment options. However, despite an enormous number of products that are available for dental professionals and patients, a conclusive evidence of a successful treatment is still missing (6, 7). Although most of these agents have been proposed and developed to treat dentin hypersensitivity successfully, many clinical studies have shown contradictory results. One explanation might be that in all pain studies, it is difficult to assess the subjective and individual different nature and complexity of pain. Therefore, the correct and reliable diagnosis with valid measurement and assessment of dentin hypersensitivity is a key factor in monitoring patients and judging therapeutic approaches in clinical trials.

AIM

The aim of this systematic review is to evaluate whether tactile test is better in diagnosing dentinal hypersensitivity compared to other diagnostic tests.

STRUCTURED QUESTIONS

Is there a difference between tactile test and other diagnostic tests in diagnosing dentin hypersensitivity?
Which is the best method of diagnosing dentin hypersensitivity?

PICO ANALYSIS

Population- Subjects having dentin hypersensitivity
Intervention-Tactile stimuli
Comparison- Other diagnostic tests

Outcome-Effectiveness in diagnosing dentinal hypersensitivity

NULL HYPOTHESIS

There is no difference between tactile test and other diagnostic tests in detecting dentin hypersensitivity.

IV. Materials And Methods

Sources Used

For identification of studies included or considered for this review, detailed search strategies were carried out on the following databases.

PubMed (until August 2013)

PubMed Advanced Search (until August 2013)

Medline

Cochrane Database of Systematic Reviews

No Limits and language restriction were applied during the electronic search to include all the possible clinical trials in the potential relevant article search phase of the systematic review. No time restriction was applied. Reference list of the reviews and of the identified randomized trials were also checked for possible additional studies

Hand searching

Journal of Oral Sciences

Journal of Periodontology

Journal of Oral Rehabilitation

Journal of clinical Periodontology

Journal of Dentistry

TABLE 1: SEARCH METHODOLOGY

Search	Query	Items found
#57	Search ((((((((((((((((((((((((teeth) OR dentin) OR dentine) OR dentinal) OR root) OR cervical) OR oral) OR pulpal) OR cementum) OR cemental) OR non carious tooth loss) OR tooth wear) OR attrition) OR abrasion) OR erosion) OR abfraction) OR non carious cervical lesion)) AND ((((((((((sensitive) OR sensitivity) OR hypersensitivity) OR hypersensitive) OR hyperesthesia) OR hyperpathia) OR hyperalgesia) OR pain) OR odontalgia) OR dentin hypersensitivity) OR dentinal hypersensitivity)) AND ((((tactile stimuli) OR tactile) OR probe) OR yeaple)) AND (((((cold) OR cold water) OR water) OR air) OR air blast)) AND (((effectiveness) OR efficacy) OR reduction in hypersensitivity)) AND (((((randomised control trial) OR randomised controlled clinical trial) OR randomised controlled trial) OR randomised clinical trial) OR randomized)) AND ((dentifrice) OR toothpaste)	60
#56	Search (dentifrice) OR toothpaste	6744
#55	Search toothpaste	3664
#54	Search dentifrice	5826
#52	Search ((((randomised control trial) OR randomised controlled clinical trial) OR randomised controlled trial) OR randomised clinical trial) OR randomized	585014
#51	Search randomized	580485
#50	Search randomised clinical trial	432151
#49	Search randomised controlled trial	437420
#48	Search randomised controlled clinical trial	12673
#47	Search randomised control trial	18185
#46	Search ((effectiveness) OR efficacy) OR reduction in hypersensitivity	703106
#45	Search reduction in hypersensitivity	8876
#44	Search efficacy	466314
#43	Search effectiveness	258428
#42	Search ((((cold) OR cold water) OR water) OR air) OR air blast	964864
#41	Search air blast	592
#40	Search air	227494
#39	Search water	621349

Search	Query	Items found
#38	Search cold water	13655
#37	Search cold	165710
#36	Search (((tactile stimuli) OR tactile) OR probe) OR yeaple	163086
#35	Search yeaple	42
#34	Search probe	151762
#33	Search tactile	11567
#32	Search tactile stimuli	3102
#31	Search ((((((((((sensitive) OR sensitivity) OR hypersensitivity) OR hypersensitive) OR hyperesthesia) OR hyperpathia) OR hyperalgesia) OR pain) OR odontalgia) OR dentin hypersensitivity) OR dentinal hypersensitivity	2025125
#30	Search dentinal hypersensitivity	356
#29	Search dentin hypersensitivity	2776
#28	Search odontalgia	2615
#27	Search pain	540699
#26	Search hyperalgesia	10811
#25	Search hyperpathia	10923
#24	Search hyperesthesia	1301
#23	Search hypersensitive	10584
#22	Search hypersensitivity	291951
#21	Search sensitivity	866907
#20	Search sensitive	493719
#19	Search ((((((((((((((teeth) OR dentin) OR dentine) OR dentinal) OR root) OR cervical) OR oral) OR pulpal) OR cementum) OR cemental) OR non carious tooth loss) OR tooth wear) OR attrition) OR abrasion) OR erosion) OR abfraction) OR non carious cervical lesion	1334628
#18	Search non carious cervical lesion	57
#17	Search abfraction	98
#16	Search erosion	19690
#15	Search abrasion	6775
#14	Search attrition	7015
#13	Search tooth wear	5726
#12	Search non carious tooth loss	164
#11	Search cemental	259
#10	Search cementum	4337
#9	Search pulpal	3845
#8	Search oral	786402
#7	Search cervical	381654
#6	Search root	161302
#5	Search dentinal	3434
#4	Search dentine	27274
#3	Search dentin	25294
#2	Search teeth	174594

INCLUSION CRITERIA

Criteria for considering studies for this review

Types of studies

Randomized controlled trials in which the tactile stimulation is used for testing dentinal hypersensitivity along with other diagnostic aids.

Types of Participants

Patients of age greater than 18 years having dentin hypersensitivity.

Types of Interventions

Dentin hypersensitivity evaluated using tactile stimulus after the daily home use of dentifrice.

Types of Outcome Measures

Effectiveness of diagnosing dentinal hypersensitivity by tactile stimuluscompared to other methods of diagnosis.

EXCLUSION CRITERIA

The following studies were excluded
Studies comparing dentifrice to in office application
Studies in which desensitizing agents other than dentifrices were used

V. Data Collection and Analysis

Study Selection:

The title, keywords and abstracts of reports identified from electronic searching for evidence of following criteria were examined:
Randomized controlled trials in which the tactile stimulation is used for testing dentinal hypersensitivity along with other diagnostic aids

Data Extraction:

Data extraction form was piloted based on several papers and modified as required before use. All studies meeting the inclusion criteria then underwent quality assessment and data extraction. Studies rejected at this or subsequent stages were listed as excluded studies.

For each trial the following data were recorded:

Year of publication, and country of origin
Details of participants including demographic characteristics and criteria for inclusion
Details of the type of intervention
Details of outcome reported (Method of assessment and mean duration of study)

CHART 1: SEARCH FLOW CHART

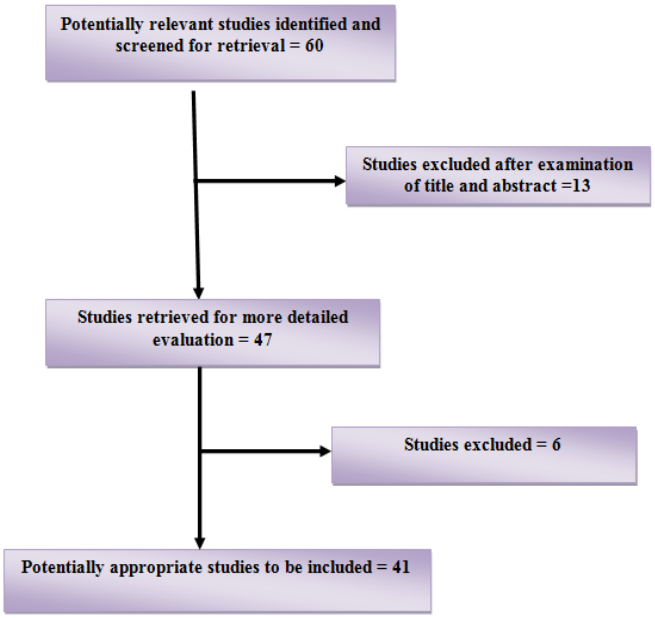


TABLE 2: VARIABLES OF INTEREST

S.NO	VARIABLES OF INTEREST
1	Tactile test Vs air blast test
2	Tactile test Vs Cold test
3	Tactile test Vs thermal test

4	Tactile test Vs Subjective patient response/VAS

TABLE 3: CHARACTERISTICS OF EXCLUDED STUDIES

S No	Author and Year	Reason for Exclusion
	Boneta et al, 2013	Desensitising mouthwash has been used in the study
	Orsini et al, 2013	Desensitising mouthwash has been used in the study
	Hu et al,2013	Desensitising mouthwash has been used in the study
	Hamlin et al, 2012	Study compared dentifrice to in office application
	Patsouri et al, 2011	Study compared dentifrice to in office application
	Schiff et al, 2009	Study compared dentifrice to in office application
	Leight et al, 2008	Desensitizing foam has been used in the study
	Poulsen et al, 2006	Review article
	Aswapati et al, 2005	No tactile has been performed and the study has evaluated gingival and plaque indices
	Pererira et al, 2001	Desensitising mouthwash has been used in the study
	Orchardson et al, 2000	Review article
	Yates et al, 1998	Desensitising mouthwash has been used in the study
	Gilliam et al, 1996	Desensitising mouthwash has been used in the study
	Parkinson et al, 2013	Full text was not retrievable
	Fu et al, 2010	Full text was not retrievable
	Milleman et al, 2012	Study comparing dentifrice to in office application
	Docimo et al, 2009	Duplicate
	Ayad et al, 2009	Duplicate
	Kobler et al, 2008	Desensitizing agent other than dentifrice was used

VI. Results

Description of Studies

The search identified 60 publications out of which 13 publications were excluded after reviewing the title or abstract. Full articles were obtained for 47 studies. A total of 42 publications fulfilled all criteria for inclusion.

TABLE 4: GENERAL INFORMATION OF SELECTED ARTICLES

S.No	Author and Year	Study design	Country	Setting	Sample size	Age	Materials used		Variables evaluated	Duration
							Test group	Control group		
1	Kakar et al, 2012	Randomized single centre, parallel group double blind controlled clinical trial	India	Clinic	88 subjects	18-70 years	8% Arginine+ CaCO3+ 1000ppm MFP	2% potassium ion as KNO3	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
2	Kakar et al, 2012	Randomized single centre, parallel group double blind controlled clinical trial	India	Clinic	74 subjects	18-70 years	8% Arginine+ CaCO3+ 1000ppm MFP	1000ppm MFP	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
3	Liu et al, 2012	Randomized, double blind, parallel group controlled trial	China	University	81 subjects	20-65 years	2% SrCl2 + 5% KNO3 In silica base	Placebo	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	3 days
4	Chanknis et al, 2011	Randomized, double blind, three treatment parallel group controlled trial	USA	Clinic	120 subjects	18-70 years	Group 1: 0.3% triclosan+ 2.0% PVM/MA+ 0.243% NaF Group 2: 0.454% NaF+ HMP+ zinc lactate	0.243% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
5	He et al, 2011	Randomized, examiner blind, two treatment, parallel group controlled clinical trial	USA	Clinic	111 subjects	18-65 years	0.454% SnF	0.76% MFP	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index and VAS)	2 weeks
6	Que et al,	Randomized,	China	University	121	18-70	Group 1: 8%	CaCO3+	Tactile stimulus	8 weeks

	2010	double blind, three treatment design, stratified controlled trial			subjects	years	Arginine+ high cleaning CaCO3+ 1450ppm MFP Group 2: 8% Arginine+ CaCO3+ 1450ppm MFP	1000ppm MFP	(Yeaple probe), air blast test (Schiff Air Index)	
7	Long Xing Ni et al 2010	Randomized, double blind, parallel group controlled clinical trial	China	Clinic	60 subjects	18 to 65 years	1450ppm NaF	5%KNO3	Tactile stimulus (Yeaple probe), thermal stimulus (Schiff Air Index)	8 weeks
8	Salian et al, 2010	Randomized, double blind, parallel group, controlled clinical trial	India	University	30 subjects	20-50 years	Group 1: 5% KNO3 Group 2: 5% Novamin	placebo	Tactile stimulus, air blast, cold water	4 weeks
9	Litkowski et al, 2010	Randomized double blind placebo controlled pilot study	USA	University	66 subjects	39.2 years (Mean age)	Group 1: 2.5% Novamin Group 2: 7.5% Novamin	Placebo	Tactile stimulus (Yeaple probe), air blast test (VAS)	8 weeks
10	Schiff et al 2011	Randomized, double blind, switch over design clinical trial	USA	Clinic	121 subjects	18-70 years	Group 1: 8% Arginine+ CaCO3+ 1450ppm NaF Group 2: 8% Strontium acetate+1040ppm NaF	-	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	16 weeks
11	Docimo et al, 2011	Randomized, double blind, parallel group, stratified controlled clinical trial	USA		150 subjects	20-69 years	Group 1: 8% Arginine+ CaCO3+ 1450ppm NaF Group 2: 8% Strontium acetate+1040ppm NaF	1100 ppm NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
12	Li et al 2011	Randomized, double blind, parallel group, stratified controlled clinical trial	USA	University	150 subjects	18-70 years	8% Strontium acetate+1040ppm NaF	Positive control: 8% Arginine+ CaCO3+ 1450ppm MFP Negative control: 1100ppm NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	7 days
13	Narongdej et al 2010	Randomized, double blind, controlled clinical trial	Bangkok	University	60 subjects	26 to 70 years	Group 1: 100% BAG powder with BAG dentifrice Group 2: NaHCO3 powder with BAG dentifrice (group2)	Placebo powder with KNO3 dentifrice	Cold stimulus, tactile stimulus	4 weeks
14	Hughes et al, 2010	Randomized, examiner blind, parallel group, stratified clinical trial	UK	University	79 subjects	26 years (Mean age)	8% strontium acetate + 1040ppm NaF	8% Arginine+ CaCO3+ 1450ppm MFP	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index), VAS	8 weeks
15	Mason et al, 2010	Randomized, examiner blind, parallel group, stratified controlled clinical trial	UK	Clinic	79 subjects	42 years (Mean age)	8% strontium acetate + 1040ppm NaF	1450ppm NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index), VAS	3 days
16	Prasad et al 2010	Randomized, examiner blind, two arm parallel design controlled clinical trial	India	University	60 subjects	18-65 years	Potassium citrate+ zinc citrate+ triclosan+ MFP	NaF+ Si+triclosan+ copolymer	Tactile stimulus, hot and cold stimulus (Thermoelectric probe)	12 weeks
17	Orsini et al, 2010	Randomized, double blind,	Italy	University	70 subjects	18-75 years	Zinc carbonate hydroxyapatite	5%KNO3+ 1450ppm NaF	Tactile stimulus (Explorer), Air	8 weeks

		controlled clinical trial					nanocrystals		blast test, cold water test, Subjective tests	
18	Docimo et al, 2009	Randomized, double blind, parallel group, stratified controlled clinical trial	Italy	Clinic	80 subjects	18-70 years	8% Arginine+ CaCO3+ 1450ppm MFP	5%KNO3+ 1450ppm NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
19	Nathoo et al, 2009	Randomized, double blind, parallel group, stratified controlled clinical trial	USA	Clinic	125 subjects	18-70 years	Group 1: 8% Arginine+ CaCO3+ 1450ppm NaF Group 2: 5%KNO3+ 1450ppm NaF	1450ppm NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	3 days
20	Ayad et al, 2009	Randomized, double blind, parallel group, stratified controlled clinical trial	USA	Research centre	120 subjects	18-70 years	Group 1: 8% Arginine+ CaCO3+ 1450ppm MFP Group 2: 5%KNO3+ 1450ppm NaF	1450ppm MFP	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	3 days
21	Docimo et al	Randomized, double blind, two treatment design, stratified clinical trial	Italy	University	75 subjects	18-70 years	5.5% Potassium citrate+1.14% MFP+ 2% Zinc citrate	3.75% Potassium chloride+ 0.32% NaF+ 0.3% Triclosan	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	4 weeks
22	Schiff et al 2005	Randomized, double blind, parallel group, controlled clinical trial	USA	University	77 subjects	18-65 years	0.454% SnF+ Sodium hexametaphosphate	0.243% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
23	Schiff et al 2005	Randomized, double blind, parallel group, controlled clinical trial	USA	University	77 subjects	18-65 years	0.454% SnF+ Sodium hexametaphosphate	0.243% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
24	Hu et al, 2004	Randomized double blind, stratified controlled clinical study	China	University	80 subjects	18-70 years	5.5% potassium citrate+1.14% MFP+10% high cleaning Silica	3.75% potassium chloride+0.32% NaF+0.3% Triclosan	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
25	Schiff et al, 2000	Randomised, double blind, parallel group controlled clinical trial	USA	Clinic	121 subjects	36 years (Mean age)	5%KNO3+ 0.454% SnF	Positive control: 5%KNO3+ 0.243% NaF Negative control: 0.243% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
26	Conforti et al, 2000	Randomized, examiner blind, stratified controlled clinical trial	USA	Clinic	66 subjects	42 years (Mean age)	5%KNO3+ 0.454% SnF	0.243% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	14 days
27	Sowinski et al, 2000	Randomized, double blind, stratified three treatment design, controlled clinical trial	USA	University	109 subjects	18-70 years	5%KNO3+ 0.454% SnF	Positive control: 5%KNO3+ 0.243% NaF Negative control: 0.243% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
28	Sowinski et al, 2000	Randomized, examiner blind, controlled clinical trial	USA	University	98 subjects	18-70 years	5%KNO3+ 0.454% SnF	5%KNO3+ 0.76% MFP	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
29	Schiff et al, 2000	Randomized, examiner blind, controlled	USA	University	101 subjects	18-70 years	5%KNO3+ 0.454% SnF	5%KNO3+ 0.76% MFP	Tactile stimulus (Yeaple probe), air blast test (Schiff Air	8 weeks

		clinical trial							Index)	
30	Sowinski et al, 2001	Randomized, double blind, stratified parallel design, controlled clinical trial	USA	Clinic	Study 1: 81 Study 2: 105 subjects	18-70 years	10%KNO3+ 0.59% SnF+ 0.32% NaF	0.32% NaF Or 3.75% KCl2+ Triclosan+ 0.32% NaF	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
31	Schiff et al, 1998	Randomized, double blind, stratified, controlled clinical trial	USA	University	43 subjects	33 years (Mean age)	5%KNO3+ 1500ppm MFP	Placebo	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	8 weeks
32	Plagmann et al, 1997	Randomized, double blind, parallel group, controlled clinical trial	Germany	University	115 subjects	18-58 years	Group 1: 1400ppm AF Group 2: 1400ppm NaF	Placebo	Tactile stimulus (Yeaple probe), air blast test (VAS)	8 weeks
33	West et al, 1997	Randomized, double blind, parallel group, clinical trial	UK	University	131 subjects	18-65 years	Group 1: Strontium acetate+ NaF Group 2: KNO3+ NaF Group 3: MFP	-	Tactile stimulus (straight probe), air blast test (VAS)	6 weeks
34	Silverman et al 1996	Randomized, double blind, placebo controlled parallel group clinical trial	USA	Clinic	230 subjects	18 years and above	Group 1: 5% KNO3+ 0.243% NaF, Group 2: 5% KNO3, Group 3: 10% SrCl2	Placebo.	Tactile stimulus (Yeaple probe), air blast test (VAS)	8 weeks
35	Nagata et al, 1994	Randomized, double blind, clinical trial	Japan	University	36 Subjects	29-63 years	5% KNO3	Placebo	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index)	12 weeks
36	Silverman et al, 1994	Randomized, double blind, parallel, controlled clinical trial	USA	Clinic	62 subjects	19-65 years	Group 1: KCl+MFP Group 2: KCl	placebo	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index), Overall sensitivity VAS	8 weeks
37	Ayad et al, 1994	Randomized, double blind, clinical trial	USA	Clinic	97 subjects	Adult	Group 1: 5% KNO3+ 1.3% soluble pyrophosphate+ 1.5% PVM/MA+ 0.243% NaF Group 2: 5% KNO3+ 0.76% MFP	-	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index) VAS	12 weeks
38	Schiff et al, 1994	Randomized, double blind, clinical trial	USA	Clinic	67 subjects	Adult	5% KNO3+ 1.3% soluble pyrophosphate+ 1.5% PVM/MA+ 0.243% NaF	Placebo	Tactile stimulus (Yeaple probe), air blast test (Schiff Air Index), thermal sensitivity (Thermal probe), VAS	12 weeks
39	Salvatoet al, 1992	Randomized, double blind, parallel, controlled clinical trial	USA	Clinic	41 subjects	18-65 years	KCl+MFP	placebo	Tactile stimulus (Yeaple probe), air blast test, Overall sensitivity VAS	12 weeks
40	Gilliam et al, 1991	Randomized, double blind, parallel group, clinical trial	London	University	49 subjects	42.8 years (Mean)	SCH+Silica	SCH+ Diatamaceous earth	Tactile stimulus (Yeaple probe), cold air test (VAS)	8 weeks
41	Minkoff et al, 1986	Randomized, double blind parallel group controlled clinical trial	USA	Clinic	61 subjects	18- 65 years	Strontium Chloride hexahydrate	Placebo	Tactile stimulus (Elctronic probe), thermal stimulus, Overall subjective sensitivity	12 weeks

TABLE 5: GENERAL INFORMATION OF VARIABLE OF INTERESTS
TACTILE TEST-YEAPLE PROBE Vs. AIRBLAST TEST

S.NO	AUTHOR & YEAR	FOLLOW UP	OUTCOME
	Kakar et al, 2012	2, 4 and 8 weeks	Tactile test showed 19.8% (2 weeks) more reduction, 2% (4 weeks) more reduction and 29.1% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 8% Arginine+CaCO3+MFP group and KNO3+NaF group
	Kakar et al, 2012	2, 4 and 8 weeks	Tactile test showed 42.4% (2 weeks) more reduction, 33.8% (4 weeks) more reduction and 40% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 8% Arginine+CaCO3+MFP group and 1000ppm MFP group.
	Liu et al 2012	Immediate and 3 days	Tactile test showed 35.53% (Immediate) and 32.46% (3 days) more reduction in hypersensitivity than air blast test in 2% SrCl2+5%KNO3 group. Tactile test showed 10.9% (Immediate) and 8.13% (3 days) more reduction in hypersensitivity than air blast test in placebo group.
	Chaknis et al, 2011	4 and 8 weeks	Tactile test showed 26.1% more reduction than air blast on comparing 0.3% Triclosan+2% PVM/MA+0.243% NaF group and 0.454% SnF+HMP+Zinc lactate group, 11.4% more reduction than air blast on comparing .3% triclosan+2% PVM/MA+0.243% NaF group and 0.243% NaF and 18.2% less reduction than air blast on comparing 0.454% SnF+HMP+Zinc lactate and 0.243% NaF group during 4 weeks evaluation. Tactile test showed 10.7% more reduction than air blast on comparing 0.3% Triclosan+2% PVM/MA+0.243% NaF group and 0.454% SnF+HMP+Zinc lactate group, 27.1% more reduction than air blast on comparing .3% Triclosan+2% PVM/MA+0.243% NaF group and 0.243% NaF and 7.6% more reduction than air blast on comparing 0.454% SnF+HMP+Zinc lactate and 0.243% NaF group during 4 weeks evaluation.
	He et al, 2011	3 days and 2 weeks	Tactile test showed 154.2% (3 days) more reduction and 177.7% (2 weeks) more reduction in hypersensitivity than air blast test on comparing 0.454% SnF group and 0.76% MFP group.
	Que et al, 2010	2, 4 and 8 weeks	Tactile test showed 5.5% (2 weeks) more reduction, 0.7% (4 weeks) more reduction and 6% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 16.8% Arginine + high cleaning CaCO3+1450ppm MFP group and 8% Arginine+CaCO3+1450ppm MFP group. Tactile test showed 23.7% (2 weeks) more reduction, 12.3% (4 weeks) more reduction and 13.4% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 8% Arginine + high cleaning CaCO3+1450ppm MFP group and CaCO3+1450ppm MFP group. Tactile test showed 19.3% (2 weeks) more reduction, 9.6% (4 weeks) more reduction and 18.5% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 8% Arginine + CaCO3+1450ppm MFP group and 8% Arginine+CaCO3+1450ppm MFP group.
	Long Xing et al, 2010	4 and 8 weeks	Tactile test showed 47.4% (4 weeks) and 88.6% (8 weeks) more reduction in hypersensitivity than air blast test in 1450ppm NaF group. Tactile test showed 57.9% (4 weeks) and 94.3% (8 weeks) more reduction in hypersensitivity than air blast test in 1450ppm NaF group.
	Schiff et al, 2011	8, 10 and 16 weeks	Tactile test showed 11.9% (8 weeks) more reduction, 7% (10 weeks) less reduction and 6% (16 weeks) less reduction in hypersensitivity on comparing 8% Arginine+CaCO3+1450ppm MFP group and 8% strontium acetate+1040ppm NaF group.
	Docimo et al, 2011	2, 4 and 8 weeks	Tactile test showed 16.8% more reduction than air blast on comparing colgate sensitive pro-relief and Sensodyne rapid relief group, 38% more reduction than air blast on comparing colgate sensitive pro-relief and crest cavity protection group and 12.4% more reduction than air blast on comparing Sensodyne rapid relief group and crest cavity protection group during 2 weeks evaluation. Tactile test showed 6% less reduction than air blast on comparing colgate sensitive pro-relief and Sensodyne rapid relief group, 70.3% more reduction than air blast on comparing colgate sensitive pro-relief and crest cavity protection group and 30% more reduction than air blast on comparing Sensodyne rapid relief group and crest cavity protection group during 4 weeks evaluation. Tactile test showed 32.3% more reduction than air blast on comparing colgate sensitive pro-relief and Sensodyne rapid relief group, 64.8% more reduction than air blast on comparing colgate sensitive pro-relief and crest cavity protection group and 38.5% more reduction than air blast on comparing Sensodyne rapid relief group and crest cavity protection group during 8 weeks evaluation.
	Li et al, 2011	Immediate and 7 days	Tactile test showed 39.1% more reduction than air blast on comparing colgate sensitive pro-relief and Sensodyne rapid relief group, 46.2% more reduction than air

			blast on comparing colgate sensitive pro-relief and crest cavity protection group and 0.1% more reduction than air blast on comparing Sensodyne rapid relief group and crest cavity protection group on immediate evaluation after application of respective dentifrice. Tactile test showed 18.3% less reduction than air blast on comparing colgate sensitive pro-relief and Sensodyne rapid relief group, 10.2% less reduction than air blast on comparing colgate sensitive pro-relief and crest cavity protection group and 1.4% more reduction than air blast on comparing Sensodyne rapid relief group and crest cavity protection group after 7 days evaluation.
	Hughes et al, 2010	2, 4 and 8 weeks	Tactile test showed 13% (2 weeks) more reduction, 39% (4 weeks) more reduction and 38% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 8% strontium acetate+1040ppm NaF group and 8% Arginine+CaCO3+1450ppm MFP group.
	Mason et al, 2010	Immediate and 3 days	Tactile test showed 57.2% (Immediate) more reduction and 62% (3 days) more reduction in hypersensitivity than air blast test on comparing 8% strontium acetate+1040ppm NaF group and 1450ppm NaF group.
	Docimo et al, 2009	1, 2, 4 and 8 weeks evaluation	Tactile test showed 28.9% (1 week), 22.1% (2 weeks), 2.5% (4 weeks) more reduction and 22.2% (8 weeks) less reduction than air blast on comparing 8% Arginine+1450ppm MFP group and 5% KNO3+1450ppm group.
	Nathoo et al, 2009	Immediate and 3 days	Tactile test showed 101.4% more reduction than air blast on comparing 8% Arginine+CaCO3 and 5% KNO3 group, 122.2% more reduction than air blast on comparing 8% Arginine+CaCO3 and control group and 11.9% more reduction than air blast on comparing 5% KNO3 group and control group on immediate evaluation after application of respective dentifrice. Tactile test showed 77% more reduction than air blast on comparing 8% Arginine+CaCO3 and 5% KNO3 group, 110.3% more reduction than air blast on comparing 8% Arginine+CaCO3 and control group and 11.3% more reduction than air blast on comparing 5% KNO3 group and control group after 3 days evaluation.
	Ayad et al 2009	Immediate and 3 days	Tactile test showed 86.9% more reduction than air blast on comparing 8% Arginine+CaCO3 and 5% KNO3 group, 89.9% more reduction than air blast on comparing 8% Arginine+CaCO3 and control group and 6.6% less reduction than air blast on comparing 5% KNO3 group and control group on immediate evaluation after application of respective dentifrice. Tactile test showed 60.4% more reduction than air blast on comparing 8% Arginine+CaCO3 and 5% KNO3 group, 82.9% more reduction than air blast on comparing 8% Arginine+CaCO3 and control group and 0.4% less reduction than air blast on comparing 5% KNO3 group and control group after 3 days evaluation.
	Docimo et al, 2007	2 and 4 weeks	Tactile test showed 7.25% (2 weeks) more reduction and 1.95% (4 weeks) less reduction in hypersensitivity than air blast test on comparing 5.5% potassium citrate+1.14% MFP+2% zinc citrate group and 3.75% potassium chloride+0.32% NaF+0.2% Triclosan group
	Schiff et al, 2005	4 and 8 weeks	Tactile test showed 97.6% (4 weeks) more reduction and 145.7% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 0.454% SnF+HMP group and 0.243% NaF group.
	Schiff et al, 2006	4 and 8 weeks	Tactile test showed 146.9% (4 weeks) more reduction and 115% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 0.454% SnF+HMP group and 0.243% NaF group.
	Hu et al, 2004	4 and 8 weeks	Tactile test showed 5.55% (4 weeks) less reduction and 2.23% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 5.5% potassium citrate+1.14% MFP+10% high cleaning silica group and 3.75% potassium chloride+0.32% NaF+0.2% Triclosan group
	Schiff et al, 2000	4 and 8 weeks	Tactile test showed 75.91% (4 weeks) less reduction and 130.9% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 5% KNO3+0.243% NaF group. Tactile test showed 124.9% (4 weeks) less reduction and 203.6% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 0.243% NaF group. Tactile test showed 53.5% (4 weeks) less reduction and 63.7% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.243% NaF group and 0.243% NaF group.
	Conforti et al, 2000	3, 7, 10 and 14 days	Tactile test showed 29.3% (3 days) more reduction, 35% (7 days) more reduction, 73.8% (10 days) more reduction and 95.1% (14 days) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 0.243% NaF group
	Sowinski et al, 2000	4 and 8 weeks	Tactile test showed 64.9% (4 weeks) more reduction and 133.1% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 5%KNO3 +0.243% NaF group.

			Tactile test showed 122% (4 weeks) more reduction and 254.7% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 0.243% NaF group. Tactile test showed 19.2% (4 weeks) more reduction and 97.5% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5%KNO3 +0.243% NaF group and 0.243% NaF group.
	Sowinski et al, 2000	4 and 8 weeks	Tactile test showed 66.9% (4 weeks) more reduction and 89.4% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 5%KNO3 +0.76% MFP group
	Schiff err al, 2000	4 and 8 weeks	Tactile test showed 235.7% (4 weeks) more reduction and 126.8% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.454% SnF group and 5%KNO3 +0.76% MFP group
	Sowinski et al, 2000	4 and 8 weeks	Tactile test showed 74.3% (4 weeks) more reduction and 63.01% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+ SnF+NaF group and NaF group. Tactile test showed 87.8% (4 weeks) more reduction and 88.9% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+SnF+NaF group and NaF+potassiumchloride+Triclosan group.
	Schiff et al, 1998	4 and 8 weeks	Tactile test showed 16% (4 weeks) less reduction and 20.3% (8 weeks) less reduction in hypersensitivity than air blast test on comparing 5% KNO3+1500ppm MFP+CaCO3 group and placebo group
	Plagmann et al, 1997	2, 4, 6 and 8 weeks	Tactile test showed 4.3% (2 weeks) more reduction, 1% (4 weeks) less reduction, 8.3% (6 weeks) more reduction and 21.3% (8 weeks) more reduction in hypersensitivity than air blast test on comparing Amine fluoride and NaF group. Tactile test showed 7% (2 weeks) less reduction, 7.9% (4 weeks) more reduction, 22.8% (6 weeks) more reduction and 19.3% (8 weeks) more reduction in hypersensitivity than air blast test on comparing Amine fluoride group and placebo group. Tactile test showed 9% (2 weeks) less reduction, 9.6% (4 weeks) more reduction, 14.4% (6 weeks) more reduction and 4.2% (8 weeks) less reduction in hypersensitivity than air blast test on comparing NaF group and placebo group.
	Addy et al, 1997	2 and 6 weeks	Tactile test showed 6% less reduction in hypersensitivity then air blast test overall.
	Silverman et al, 1996	2, 4 and 8 weeks	Tactile test showed 7.3% (2 weeks), 5.7% (4 weeks) and 17.3% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3+0.243% NaF and placebo group. Tactile test showed 11.1% (2 weeks), 17.1% (4 weeks) and 1.9% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3 and placebo group. Tactile test showed 0.4% (2 weeks), 13.6% (4 weeks) less reduction and 9.3% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 10% SrCl2 and placebo group.
	Nagata et al, 1994	2, 4, 8 and 12 weeks	Tactile test showed 9% (2 weeks) less reduction, 0% (4 weeks) reduction/no difference, 6% (8 weeks) more reduction and 2% (12 weeks) more reduction in hypersensitivity than air blast test in 5% KNO3 group. Tactile test showed no difference (2 weeks), 2% (4 weeks) more reduction, 1% (8 weeks) less reduction and 5% (12 weeks) less reduction in hypersensitivity than air blast test in placebo group.
	Ayad et al, 1994	6 and 12 weeks	Tactile test showed 11.25% (6 weeks) less reduction and 8.8% (12 weeks) more reduction in hypersensitivity than air blast test on comparing Sensodyne F group and sensitive/tartar control group.
	Schiff et al, 1994	6 and 12 weeks	Tactile test showed 20.7% (6 weeks) and 14.7% (12 weeks) less reduction in hypersensitivity than air blast on comparing 5%KNO3+1.3% soluble pyrophosphate +1.5% PVM/MA+0.243% NaF and 5% placebo group.
	Gilliam et al, 1991	4 and 8 weeks	Tactile test showed 21.5% (2 weeks), 21.3% (4 weeks) and 25.8% (8 weeks) more reduction in hypersensitivity than air blast test in SCH+silica group. Tactile test showed 19.7% (2 weeks), 26.1% (4 weeks) and 19.7% (8 weeks) more reduction in hypersensitivity than air blast test in SCH + diatomaceous earth group.

TACTILE TEST-OTHER PROBES Vs. AIR BLAST TEST

S.NO	AUTHOR & YEAR	FOLLOW UP	OUTCOME
1	Salian et al, 2010	2 and 4 weeks	Tactile test showed 10.7% (2 weeks) less reduction and 70.9% (4 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3 group and 5% Novamin group. Tactile test showed 0.23% (2 weeks) less reduction and 1.6% (4 weeks) more reduction in hypersensitivity than air blast test on comparing 5% KNO3 group and placebo group. Tactile test showed 5% (2 weeks) less reduction and 8.1% (4 weeks) more reduction in hypersensitivity than air blast test on comparing 5% Novamin group and placebo group.
2	Orsini et al, 2010	4 and 8 weeks	Tactile test showed 7.4% (4 weeks) and 6.7% (8 weeks) more reduction in hypersensitivity than air blast in Nano carbonate hydroxyapatite group. Tactile test showed 8.9% (4 weeks) less reduction and 2.6% (8 weeks) more reduction in hypersensitivity than air blast in 5% KNO3+1450ppm NaF group.

TACTILE TEST Vs. COLD TEST

S. NO	AUTHOR & YEAR	FOLLOW UP	OUTCOME
1	Salian et al, 2010	2 and 4 weeks	Tactile test showed 12.3% (2 weeks) less reduction and 73% (4 weeks) more reduction in hypersensitivity than cold test on comparing 5% KNO3 group and 5% Novamin group. Tactile test showed 12.3% (2 weeks) less reduction and 73% (4 weeks) more reduction in hypersensitivity than cold test on comparing 5% KNO3 group and placebo group. Tactile test showed 1.83% (2 weeks) more reduction and 11% (4 weeks) less reduction in hypersensitivity than cold test on comparing 5% Novamin group and placebo group.
2	Narongdej et al, 2010	Immediate, 1, 2 and 4 weeks	Tactile test showed 8.6% (Immediate) less reduction, 14.9% (1 week) less reduction, 18.2% (2 weeks) less reduction and 36% (4 weeks) less reduction in hypersensitivity than cold test on comparing Novamin powder group and Novamin toothpaste group. Tactile test showed 11.6% (Immediate) less reduction, 20.8% (1 week) less reduction, 12.1% (2 weeks) less reduction and 25.4% (4 weeks) less reduction in hypersensitivity than cold test on comparing Novamin powder group and placebo group. Tactile test showed 4.1% (Immediate) less reduction, 13.7% (1 week) less reduction, 15.6% (2 weeks) more reduction and 27.8% (4 weeks) less reduction in hypersensitivity than cold test on comparing Novamin toothpaste group and placebo group.
3	Prasad et al, 2010	6 and 12 weeks	Tactile test showed 23.21% (6 weeks) less reduction, 16.97% (12 weeks) less reduction and 2.46% (6-12 weeks) more reduction in hypersensitivity than cold test in Anchor toothpaste group. Tactile test showed 5.57% (6 weeks) less reduction, 2.28% (12 weeks) less reduction and 3.76% (6-12 weeks) more reduction in hypersensitivity than cold test in Colgate toothpaste group.
4	Orsini et al, 2010	4 and 8 weeks	Tactile test showed 4.3% (4 weeks) less reduction and 3% (8 weeks) less reduction in hypersensitivity than cold water test in Nano carbonate hydroxyapatite group. Tactile test showed 27.3% (4 weeks) less reduction and 30.9% (8 weeks) less reduction in hypersensitivity than cold water test in 5% KNO3+1450ppm NaF group.

TACTILE TEST Vs. THERMAL TEST

S. NO	AUTHOR & YEAR	FOLLOW UP	OUTCOME
1	Prasad et al, 2010	6 and 12 weeks	Tactile test showed 23.21% (6 weeks) more reduction, 57.02% (12 weeks) more reduction and 28.09% (6-12 weeks) more reduction in hypersensitivity than thermal test in Anchor toothpaste group. Tactile test showed 41.83% (6 weeks) more reduction, 55.8% (12 weeks) more reduction and 19.04% (6-12 weeks) more reduction in hypersensitivity than thermal test in Colgate toothpaste group.
2	Schiff et al, 1994	6 and 12 weeks	Tactile test showed 12.1% (6 weeks) and 12% (12 weeks) more reduction in hypersensitivity than thermal test on comparing 5%KNO3+1.3% soluble pyrophosphate +1.5% PVM/MA+0.243% NaF and 5% placebo group.

TACTILE TEST Vs. SUBJECTIVE PATIENT RESPONSE TEST/VAS

S. NO	AUTHOR & YEAR	FOLLOW UP	OUTCOME
1	He et al, 2011	3 days and 2 weeks	Tactile test showed 151.2% (3 days) more reduction and 172.4% (2 weeks) more reduction in hypersensitivity than air VAS pain test on comparing 0.454% SnF group and 0.76% MFP group.
2	Litkowski et al, 2010	2, 4 and 8 weeks	Tactile test showed 6% (2 weeks) more reduction, 15% (4 weeks) more reduction and 7% (8 weeks) more reduction in hypersensitivity than air VAS pain test in placebo group. Tactile test showed 19% (2 weeks) more reduction, 10% (4 weeks) more reduction and 6% (8 weeks) more reduction in hypersensitivity than air VAS pain test in 2.5% Novamin group. Tactile test showed 17% (2 weeks) more reduction, 12% (4 weeks) more reduction and 18% (8 weeks) more reduction in hypersensitivity than air VAS pain test in 7.5% Novamin group.
3	Hughes et al, 2010	2, 4 and 8 weeks	Tactile test showed 10% (2 weeks) more reduction, 24% (4 weeks) more reduction and 23% (8 weeks) more reduction in hypersensitivity than air VAS pain test on comparing 8% strontium acetate+1040ppm NaF group and 8% Arginine+CaCO3+1450ppm MFP group.
4	Mason et al, 2010	Immediate and 3 days	Tactile test showed 57.8% (Immediate) more reduction and 36% (3 days) more reduction in hypersensitivity than air VAS pain test on comparing 8% strontium acetate+1040ppm NaF group and 1450ppm NaF group.
5	Orsini et al, 2010	4 and 8 weeks	Tactile test showed 15.3% (4 weeks) more reduction and 5.2% (8 weeks) more reduction in hypersensitivity than subjective test in Nano carbonate hydroxyapatite group. Tactile test showed 1.9% (4 weeks) less reduction and 3.9% (8 weeks) more reduction in hypersensitivity than cold water test in 5% KNO3+1450ppm NaF group.
6	Plagmann et al, 1997	2, 4, 6 and 8 weeks	Tactile test showed 1.2% (2 weeks) more reduction, 0.7% (4 weeks) less reduction, 4% (6 weeks) more reduction and 22.4% (8 weeks) more reduction in hypersensitivity than VAS test on comparing Amine fluoride and NaF group. Tactile test showed 2.5% (2 weeks) less reduction, 6.5% (4 weeks) more reduction, 17.5% (6 weeks) more reduction and 23.5% (8 weeks) more reduction in hypersensitivity than VAS test on comparing Amine fluoride group and placebo group. Tactile test showed 3.8% (2 weeks) less reduction, 7.9% (4 weeks) more reduction, 13.8% (6 weeks) more reduction and 0.3% (8 weeks) less reduction in hypersensitivity than air blast test on comparing NaF group and placebo group.
7	Addy et al, 1997	2 and 6 weeks	Tactile test showed 22% more reduction in hypersensitivity then sensitivity/VAS test overall.
8	Silverman et al, 1996	2, 4 and 8 weeks	Tactile test showed 0.1% (2 weeks) more reduction, 8.2% (4 weeks) more reduction and 5.4% (8 weeks) less reduction in hypersensitivity than subjective test on comparing 5% KNO3+0.243% NaF and placebo group. Tactile test showed 3.5% (2 weeks), 7.2% (4 weeks) and 3.4% (8 weeks) more reduction in hypersensitivity than subjective test on comparing 5% KNO3 and placebo group.

			Tactile test showed 0.1% (2 weeks), 7.9% (4 weeks) less reduction and 2.7% (8 weeks) more reduction in hypersensitivity than air blast test on comparing 10% SrCl2 and placebo group.
9	Ayad et al, 1994	6 and 12 weeks	Tactile test showed 9.3% (6 weeks) less reduction and 16.5% (12 weeks) more reduction in hypersensitivity than VAS test on comparing Sensodyne F group and sensitive/tartar control group.
10	Schiff et al, 1994	6 and 12 weeks	Tactile test showed 19.7% (12 weeks) more reduction in hypersensitivity than subjective test on comparing 5%KNO3+1.3% soluble pyrophosphate +1.5% PVM/MA+0.243% NaF and 5% placebo group.
11	Gilliam et al, 1991	4 and 8 weeks	Tactile test showed 21.7% (2 weeks), 23% (4 weeks) and 23.8% (8 weeks) more reduction in hypersensitivity than subjective test in SCH+silica group. Tactile test showed 34.4% (2 weeks), 32% (4 weeks) and 23.9% (8 weeks) more reduction in hypersensitivity than subjective test in SCH + diatomaceous group.
12	Minkoff et al, 1986	2, 4, 8 and 12 weeks	Tactile test showed 12.4% (2 weeks) less reduction, 22.9% (4 weeks) less reduction, 26.4% (8 weeks) less reduction and 27.5% (12 weeks) less reduction in hypersensitivity than subjective test in SCH group. Tactile test showed 7.6% (2 weeks) less reduction, 6.5% (4 weeks) less reduction, 4.1% (8 weeks) more reduction and 0.2% (12 weeks) more reduction in hypersensitivity than subjective test in placebo group

SUMMATION TABLES FOR VARIABLES OF INTEREST

TABLE 6: STUDIES COMPARING TACTILE TEST Vs AIR BLAST TEST

Total No. of studies	No. of studies in which tactile test gave better result	No. of studies in which air blast test gave better result	No difference
36	30	6	-

TABLE 7: STUDIES COMPARING TACTILE TEST Vs COLD TEST

No. of studies	No. of studies in which tactile test gave better result	No. of studies in which cold test gave better result	No difference
4	1	3	-

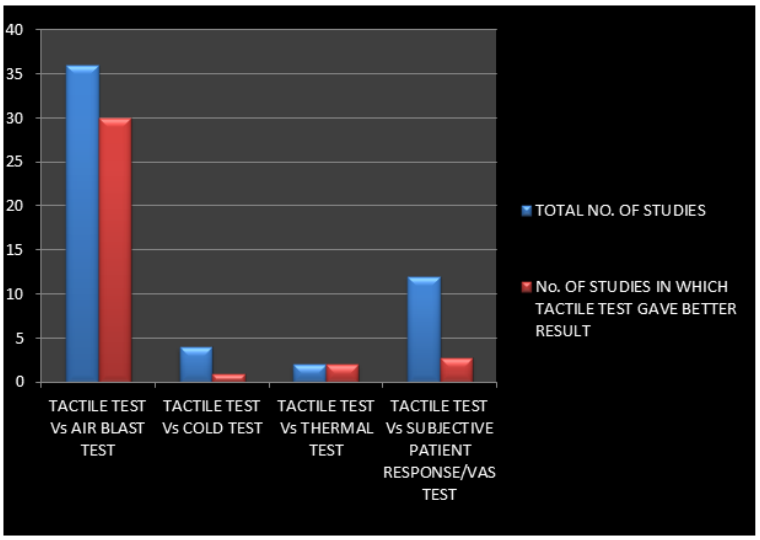
TABLE 8: STUDIES COMPARING TACTILE TEST Vs THERMAL TEST

No. of studies	No. of studies in which tactile test gave better result	No. of studies in which thermal test gave better result	No difference
2	2	-	-

TABLE 9: STUDIES COMPARING TACTILE TEST Vs SUBJECTIVE PATIENT RESPONSE/VAS TEST

No. of studies	No. of studies in which tactile test gave better result	No. of studies in which subjective patient response test gave better result	No difference
12	11	1	-

GRAPH 1: SUMMATION OF PARAMETERS



QUALITY ASSESSMENT

(Higgins and Green.Cochrane reviewer's Handbook 2009)

The quality assessment of included trials was undertaken independently as a part of data extraction process. Four main quality criteria were examined:

Method of Randomization, recorded as
Yes – Adequate as described in the text
No – Inadequate as described in the text
Unclear in the text
Allocation Concealment, recorded as
Yes – Adequate as described in the text
No – Inadequate as described in the text
Unclear in the text
Outcomes assessors blinded to intervention, recorded as
Yes – Adequate as described in the text
No – Inadequate as described in the text
Unclear in the text
Completeness of follow-up (was there a clear explanation for withdrawals and dropouts in each treatment group) assessed as:
Yes-Dropouts were explained
No-Dropouts were not explained
None -No Dropouts or withdrawals
Other methodological criteria examined included:
Presence or absence of sample size calculation
Comparability of groups at the start
Clear inclusion/ exclusion criteria
Presence/ absence of estimate of measurement error.

TABLE 10: EVIDENCE LEVEL OF SELECTEDARTICLES

S.NO	AUTHOR	STUDY DESIGN	LEVEL OF EVIDENCE
1	Kakar et al, 2012	Randomized single centre, parallel group double blind controlled clinical trial	2
2	Kakar et al, 2012	Randomized, clinical trial	2
3	Liu et al, 2012	Randomized, double blind, parallel group controlled trial	2
4	Chanknis et al, 2011	Randomized, double blind, three treatment parallel group controlled trial	2
5	He et al, 2011	Randomized, clinical trial	2
6	Que et al, 2010	Randomized, double blind, three treatment design, stratified controlled trial	2
7	Long Xing Ni et al 2010	Randomized, double blind, parallel group controlled clinical trial	2
8	Salian et al, 2010	Randomized, double blind, parallel group, controlled clinical trial	2
9	Litkowski et al, 2010	Randomized double blind placebo controlled pilot study	2
10	Schiff et al 2011	Randomized, double blind, switch over design clinical trial	2
11	Docimo et al, 2011	Randomized, double blind, parallel group, stratified controlled clinical trial	2
12	Li et al 2011	Randomized, double blind, parallel group, stratified controlled clinical trial	2
13	Narongdej et al 2010	Randomized, double blind, controlled clinical trial	2
14	Hughes et al, 2010	Randomized, examiner blind, parallel group, stratified clinical trial	2
15	Mason et al, 2010	Randomized, examiner blind, parallel group, stratified controlled clinical trial	2
16	Prasad et al 2010	Randomized, examiner blind, two arm parallel design controlled clinical trial	2
17	Orsini et al, 2010	Randomized, double blind, controlled clinical trial	2

18	Docimo et al, 2009	Randomized, double blind, parallel group, stratified controlled clinical trial	2
19	Nathoo et al, 2009	Randomized, double blind, parallel group, stratified controlled clinical trial	2
20	Ayad et al, 2009	Randomized, double blind, parallel group, stratified controlled clinical trial	2
21	Docimo et al	Randomized, double blind, two treatment design, stratified clinical trial	2
22	Schiff et al 2005	Randomized, double blind, parallel group, controlled clinical trial	2
23	Schiff et al 2005	Randomized, double blind, parallel group, controlled clinical trial	2
24	Hu et al, 2004	Randomized double blind clinical study	2
25	Schiff et al, 2000	Randomised clinical trial	2
26	Conforti et al, 2000	Randomised clinical trial	2
27	Sowinski et al, 2000	Randomized, double blind, stratified three treatment design, controlled clinical trial	2
28	Sowinski et al, 2000	Randomized, examiner blind, controlled clinical trial	2
29	Schiff et al, 2000	Randomized, examiner blind, controlled clinical trial	2
30	Sowinski et al, 2001	Randomized, double blind, stratified parallel design, controlled clinical trial	2
31	Schiff et al, 1998	Randomized clinical trial	2
32	Plagmann et al, 1997	Randomized, double blind, parallel group, controlled clinical trial	2
33	West et al, 1997	Randomized, double blind, parallel group, clinical trial	2
34	Silverman et al 1996	Randomized, double blind, placebo controlled parallel group clinical trial	2
35	Nagata et al, 1994	Randomized, double blind, clinical trial	2
36	Silverman et al, 1994	Randomized, double blind, parallel, controlled clinical trial	2
37	Ayad et al, 1994	Randomized, double blind, clinical trial	2
38	Schiff et al, 1994	Randomized, double blind, clinical trial	2
39	Salvatoet al, 1992	Randomized, double blind, parallel, controlled clinical trial	2
40	Gilliam et al, 1991	Randomized, double blind, parallel group, clinical trial	2
41	Minkoff et al, 1986	Randomized, double blind parallel group controlled clinical trial	2

RISK OF BIAS IN INCLUDED STUDIES

The assessments for the four main methodological quality items are shown in table 1. The study was assessed to have a "High risk" of bias if it did not record a "Yes" in three or more of the four main categories, "Moderate" if two out of four categories did not record a "Yes", and "Low" if randomization assessor blinding and completeness of follow – up were considered adequate.

TABLE 11: RISK OF BIAS-MAJOR CRITERIA

S. NO	Study	Randomization	Allocation Concealed	Assessor Blinded	Dropouts described	Risk of Bias
1	Kakar et al, 2012	Unclear	No	Yes	No	High
2	Kakar et al, 2012	Unclear	No	Yes	Yes	Moderate
3	Liu et al, 2012	Yes	No	Yes	Yes	Low
4	Chanknis et al, 2011	Unclear	No	Yes	Yes	Moderate
5	He et al, 2011	Unclear	No	Yes	Yes	Moderate
6	Que et al,	Unclear	No	Yes	Yes	Moderate

	2010					
7	Long Xing Ni et al 2010	Yes	No	Yes	Yes	Low
8	Salian et al, 2010	Unclear	No	Yes	No	High
9	Litkowski et al, 2010	Unclear	No	Yes	Yes	Moderate
10	Schiff et al 2011	Unclear	No	Yes	Yes	Moderate
11	Docimo et al, 2011	Unclear	No	Yes	Yes	Moderate
12	Li et al 2011	Unclear	No	Yes	Yes	Moderate
13	Narongdej et al 2010	Unclear	No	Yes	Yes	Moderate
14	Hughes et al, 2010	Unclear	No	Yes	Yes	Moderate
15	Mason et al, 2010	Unclear	No	Yes	Yes	Moderate
16	Prasad et al 2010	Unclear	No	Yes	Yes	Moderate
17	Orsini et al, 2010	Yes	Yes	Yes	Yes	Low
18	Docimo et al, 2009	Unclear	No	Yes	Yes	Moderate
19	Nathoo et al, 2009	Unclear	No	Yes	Yes	Moderate
20	Ayad et al, 2009	Unclear	No	Yes	Yes	Moderate
21	Docimo et al	Unclear	No	Yes	Yes	Moderate
22	Schiff et al 2005	Unclear	No	Yes	Yes	Moderate
23	Schiff et al 2005	Unclear	No	Yes	Yes	Moderate
24	Hu et al, 2004	Unclear	No	Yes	Yes	Moderate
25	Schiff et al, 2000	Unclear	No	Yes	Yes	Moderate
26	Conforti et al, 2000	Unclear	No	Yes	Yes	Moderate
27	Sowinski et al, 2000	Unclear	No	Yes	Yes	Moderate
28	Sowinski et al, 2000	Unclear	No	Yes	Yes	Moderate
29	Schiff et al, 2000	Unclear	No	Yes	Yes	Moderate
30	Sowinski et al, 2001	Unclear	No	Yes	Yes	Moderate
31	Schiff et al, 1998	Unclear	No	Yes	Yes	Moderate
32	Plagmann et al, 1997	Unclear	No	Yes	Yes	Moderate
33	West et al, 1997	Unclear	No	Yes	Yes	Moderate
34	Silverman et al 1996	Unclear	No	Yes	Yes	Moderate
35	Nagata et al, 1994	Unclear	No	Yes	Yes	Moderate
36	Silverman et al, 1994	Unclear	No	Yes	Yes	Moderate
37	Ayad et al, 1994	Unclear	No	Yes	Yes	Moderate
38	Schiff et al, 1994	Unclear	No	Yes	Yes	Moderate
39	Salvato et al, 1992	Unclear	No	Yes	Yes	Moderate
40	Gilliam et al, 1991	Yes	No	Yes	Yes	Low
41	Minkoff et al, 1986	Yes	No	Yes	Yes	Low

TABLE 12: RISK OF BIAS-MINOR CRITERIA

S. NO	Study	Sample Justified	Baseline Comparison	I/E Criteria	Method Error
1	Kakar et al, 2012	No	Yes	Yes	No
2	Kakar et al, 2012	No	Yes	Yes	No
3	Liu et al, 2012	No	Yes	Yes	No
4	Chanknis et al, 2011	No	Yes	Yes	No
5	He et al, 2011	No	Yes	Yes	No
6	Que et al, 2010	No	Yes	Yes	No
7	Long Xing Ni et al 2010	No	Yes	Yes	No
8	Salian et al, 2010	No	Yes	Yes	No
9	Litkowski et al, 2010	Yes	Yes	Yes	No
10	Schiff et al 2011	No	Yes	Yes	No
11	Docimo et al, 2011	No	Yes	Yes	No
12	Li et al 2011	No	Yes	Yes	No
13	Narongdej et al 2010	No	Yes	Yes	No
14	Hughes et al, 2010	Yes	Yes	Yes	No
15	Mason et al, 2010	Yes	Yes	Yes	No
16	Prasad et al 2010	No	Yes	Yes	No
17	Orsini et al, 2010	No	Yes	Yes	No
18	Docimo et al, 2009	No	Yes	Yes	No
19	Nathoo et al, 2009	No	Yes	Yes	No
20	Ayad et al, 2009	No	Yes	Yes	No
21	Docimo et al	No	Yes	Yes	No
22	Schiff et al 2005	No	Yes	Yes	No
23	Schiff et al 2005	No	Yes	Yes	No
24	Hu et al, 2004	No	Yes	Yes	No
25	Schiff et al, 2000	No	Yes	Yes	No
26	Conforti et al, 2000	No	Yes	Yes	No
27	Sowinski et al, 2000	No	Yes	Yes	No
28	Sowinski et al, 2000	No	Yes	Yes	No
29	Schiff et al, 2000	No	Yes	Yes	No
30	Sowinski et al, 2001	No	Yes	Yes	No
31	Schiff et al, 1998	No	Yes	Yes	No
32	Plagmann et al, 1997	No	Yes	Yes	No
33	West et al, 1997	No	Yes	Yes	No
34	Silverman et al 1996	No	Yes	Yes	No
35	Nagata et al, 1994	No	Yes	Yes	No
36	Silverman et al, 1994	No	Yes	Yes	No
37	Ayad et al, 1994	No	Yes	Yes	No
38	Schiff et al, 1994	No	Yes	Yes	No
39	Salvatoet al, 1992	No	Yes	Yes	No
40	Gilliam et al, 1991	No	Yes	Yes	No
41	Minkoff et al, 1986	No	Yes	Yes	No

VII. Discussion

The purpose of this review was to evaluate whether tactile stimuli is better in diagnosing dentin hypersensitivity compared to other diagnostic tests.

INTERPRETATION OF RESULTS

This review included 41 randomized controlled clinical trials in which tactile test was compared with other diagnostic tests in evaluation of dentin hypersensitivity. The studies on comparision of different diagnostic tests were not available. So, clinical studies of different dentifrices in which different diagnostic tests were done were selected and indirect measurements were taken

ASSESSMENT OF INDIVIDUAL PARAMETERS

TACTILE TEST Vs AIR BLAST TEST

Among the 41 clinical trials, 36 clinical trials evaluated the reduction in dentin hypersensitivity in patients treated with respective dentifrice by using tactile test and air blast test(8-15, 17-19, 21-22, 24-27, 28-42, 44-45, 47). Among the 36 trials, 34 trials used Yeaple probe for eliciting tactile stimuli and remaining trials used dental explorer in eliciting tactile stimuli. In all the 36 clinical trials air from a standard air/water syringe with a pressure of 45psi to 65 psi was directed towards the sensitive portion of tooth, perpendicular to long axis of the tooth at a distance of 0.5 to 1 cm. Tactile test showed more percentage reduction in dentinal hypersensitivity when compared to air blast test in 30 trials.

Among the 36 trials, 10 clinical trials used Arginine as the desensitizing agent, out of which, 9 showed significant results for tactile test when compared to air blast test. 5 clinical trials used strontium chloride as desensitizing agent, out of which, 4 trials showed significant results for tactile test. 8 clinical trials used sodium fluoride as the desensitizing agent, out of which, 6 trials showed significant results for tactile test. 10 clinical trials used potassium nitrate as desensitizing agent, out of which, 8 trials showed significant results for tactile test.

TACTILE TEST Vs COLD TEST

Among the 41 clinical trials, 4 clinical trials evaluated the reduction in dentin hypersensitivity in patients treated with respective dentifrice by using tactile test and cold test(15, 20, 23-24). Cold test showed more percentage reduction in dentinal hypersensitivity when compared to tactile test.

Out of the 4 clinical trials, 2 clinical trials used Novamin as the desensitizing agent. In the remaining 2 trials, potassium citrate, potassium nitrate and sodium fluoride were used. Cold test was effective in all the trials except in the trial which used Novamin and potassium nitrate(15).

TACTILE TEST Vs THERMAL TEST

Among the 41 clinical trials, 2 clinical trials evaluated the reduction in dentin hypersensitivity in patients treated with respective dentifrice by using tactile test and thermal test(18, 23). Tactile test showed more percentage reduction in dentinal hypersensitivity when compared to thermal test.

Tactile test showed significant results in both the clinical trials which used Arginine, potassium citrate and sodium fluoride as the desensitizing agents.

TACTILE TEST Vs SUBJECTIVE PATIENT RESPONSE TEST/VAS

Among the 41 clinical trials, 12 clinical trials evaluated the reduction in dentin hypersensitivity in patients treated with respective dentifrice by using tactile test and subjective patient response. Tactile test showed more percentage reduction in dentinal hypersensitivity when compared to subjective patient response test in 11 trials (12, 16, 21-22, 24, 39-41, 44-45, 47-48).

Among the 12 trials, 6 clinical trials used sodium fluoride as the desensitizing agent, out of which all trials showed significant results for tactile test. 5 clinical trials used potassium nitrate as the desensitizing agent, out of which, all the trials showed significant results for tactile test. 1 trial used strontium acetate, 1 trial used Arginine, 1 trial used Novamin, 1 trial used stannous fluoride as the desensitizing agents. All these trials showed significant results for tactile test when compared to subjective patient response. Strontium chloride was used in 2 trials, among which 1 trial(48) showed significant result for subjective patient response test when compared to tactile test.

DEFENDING THE RESULTS

Dentin hypersensitivity is characterized by distinctive short, sharp pain arising from exposed cervical dentin in response to various external stimuli that are typically thermal, evaporative, tactile, electrical, osmotic, or chemical, which cannot be ascribed to any other form of dental pathology, defect, or disease. Typically, dentin hypersensitivity occurs when the external stimulus contacts exposed dentin surfaces with open and patent tubules (1). The different stimuli trigger a rapid outflow of dentin fluid, and the following pressure change across the dentin activates baroreceptors near the pulp, leading to cause an immediate sharp pain (1). Tactile, cold, evaporative, and osmotic stimuli trigger the non-physiological fluid outflow. On the other hand, heat induces a slow retreat of dentin fluid, and the resultant pressure change activates the baroreceptors and nerve fibers in a less dramatic fashion, consistent with the observation that cold and evaporative stimuli are generally more painful to patients than heat.

Different methods of applying tactile stimuli include scratching the dentin surface with a sharp probe, scaling procedure as well as mechanical pressure stimulators and more recently the Yeaple probe.

The Yeaple probe is an electronic pressure sensitive device originally designed to function as a pressure controlled periodontal probe. The probe is designed to deliver a pre-set force when the tip is applied perpendicular to the tooth surface. This force may be varied by regulating the current by means of a dial to an electromagnet controlling tip position(49).

The main advantage of the Yeaple probe is that tactile sensitivity can be reported in terms of a quantifiable, reproducible force. The probe tip also affords access to all tooth surfaces.

On the other hand, cold water testing lacks objectivity. It is difficult to determine how much water has been placed on the tooth and the timing of this placement. It is also difficult to control the flow of water and confine to a specific tooth. Furthermore, the intensity of the pain perceived by the patient at the temperature which first produced a positive response was not evaluated(49). In addition to this, cold water test requires rubber dam isolation of the tested teeth and placement of rubber dam in patients with cervical dentinal hypersensitivity is difficult.

The use of prolonged air blast test has been criticized. Branstrom demonstrated that if human dentin was dried with a stream of air for 5min, it remained insensitive to painful stimuli, as long as it was kept dry. Furthermore, evaporative water loss from the dentin caused displacement of odontoblast nuclei into the tubules(49). The air blast test showed less percentage reduction in dentin hypersensitivity as the test used Schiff Cold air Sensitivity Scale, which had very few scoring system numbered from 1 to 4.

Pain is a subjective experience in which perception is based on a range of variables, including: individual personality, psychological factors, degree of fear or anxiety, cultural factors, and social influences. In view of the broad range of different expressions in response to same stimulus, objective methodology is needed to quantify subjective patient response as far as possible.

REPORT ON QUALITY OF EVIDENCE LOOKED UPON

41 trials were included in this review. All the studies included in this review are of level of evidence 2. All are randomized clinical trials, thus the level of evidence is high. Risk of biasis low in 5 clinical trials, high in 2 clinical trialsand the remaining trials had moderate risk of bias. (Table 11&12)

REPORT OF OUTLIER DATA

No outlier data obtained.

INFERENCE

IMPLICATIONS FOR PRACTICE

Tactile test (Yeaple probe) can be used in the evaluation of dentin hypersensitivity because it performed better than other diagnostic tests.

IMPLICATIONS FOR RESEARCH

Since tactile stimuli with yeaple probe has given better results, it is recommended that, it be used as a standard tool for assessing hypersensitivity quantitatively and evaluating the efficacy of new desensitizing agents.

VIII. Summary

The aim of this systematic review is to evaluate whether tactile test is better in diagnosing dentinal hypersensitivity when compared to other diagnostic tests.

The databases PubMed Central and Medline were searched for the related topic until August 2013. The search identified 60 publications out of which 13 were excluded after reviewing the title or abstract. Full articles were obtained for 47 studies, 6 of these articles were excluded after reading the full text article. Therefore a total of 41 articles fulfilled all criteria for inclusion.

This review included 41 randomized controlled trials in which effectiveness of tactile was compared with other diagnostic tests in evaluation of dentin hypersensitivity. Clinical parameters comparing tactile test with other diagnostic tests (Air blast test, Cold test, Thermal test, Subjective assessment/VAS) were checked as primary outcomes. With the available evidence, it was concluded that tactile testing, especially with Yeaple probe, performs better than other diagnostic tests in evaluation of dentin hypersensitivity. As most of the included studies have moderate risk of bias, well designed randomized controlled studies with long term follow up must be performed to give concrete evidence on the effectiveness of tactile test in evaluation of dentin hypersensitivity.

IX. Conclusion

With the available evidence, this review concludes that

Tactile test with Yeaple probe shows more percentage reduction in dentinal hypersensitivity when compared to other diagnostic tests.

Tactile testing is recommended as a better tool in diagnosing dentin hypersensitivity and in comparing efficacy of various agents in treatment of dentin hypersensitivity.

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