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Effect Of Bioactive Glass on Dentin Hypersensitivity – A Systematic Review

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ABSTRACT

Objective: To evaluate whether the dentifrice containing bioactive glass is more effective than dentifrice without bioactive glass in reduction of dentin hypersensitivity .

Is there any difference between the dentifrice containing bioactive glass and other dentifrice without bioactive glass in reduction of dentin hypersensitivity.

Sources: Five databases were searched to identify the relevant articles published up to December 2020 . Electronic databases were searched in PUBMED , Scopus ,LILACS , Cochrane Library and Google scholar . Two authors had performed the data extraction from the included studies . The primary outcome is to evaluate the response to thermal ,tactile ,cold stimulus for the treatment of dentine hypersensitivity and the secondary outcome is to compare the efficacy of desensitising agents used in the treatment of Dentine hypersensitivity. Each of the included studies was evaluated using the Cochrane Collaboration tool for assessing risk of bias .

Study Selection: Randomised controlled trials (RCTs) comparing desensitising toothpastes with a toothpaste without the desensitising components . This was evaluated in the patients who suffer from Dentin hypersensitivity were included . The risk of bias was assessed according to Cochrane guidelines using RevMan 5.3 software .

Data Collection: A total of 14 RCTs were included in this systematic review . It was clearly stated that the toothpastes that contain active desensitisation ingredients showed a better desensitising effect on Dentin hypersensitivity than that of other groups .

Conclusion: According to the 14 (RCT's) included studies in this systematic review , the bioactive glass containing dentifrice had superior reduction of dentin hypersensitivity compared to dentifrice without bioactive glass .

Keywords: *components, electronic, glass, bioactive*

INTRODUCTION

Dentin hypersensitivity is characterised by short duration of pain arising from exposed dentin in response to stimuli , typically thermal , evaporative , tactile , osmotic or chemical and which cannot be attributed to any other dental defect or pathology(Gillam, 2015) (Neuhaus KW et al) . Several studies have found the prevalence to range from 8-40 % of the adult population to 60 – 88% prevalence in periodontal patients , with peak incidence between the ages of 20 to 40 years(Soares and Grippo, 2017)

Gradual loss of enamel by tooth wear or gingival recession can lead to exposed dentine and dentine hypersensitivity(Samuel Vet al). Gingival recession or Exposure to dentine occurs by 2 mechanisms , Gingival recession and tooth wear where gingival margin migrates apically thereby exposing the cementum which is rapidly abraded away or tooth wear which is generally erosive where the enamel surface of the crown is lost exposing the dentine (Seong J, et al)(Agrawal, 2012) .Gingival recession is one of the most important predisposing factor for dentin hypersensitivity in 80% of population

Various mechanisms have been explained the development of dentin hypersensitivity , tooth sensitivity had theorised to be caused by (1) Direct nerve stimulation (2) Irritation of odontoblastic process (3) hydrodynamic flow in open dentin tubules (Seong J et al) . Most accepted theory is Hydrodynamic theory , proposed by Gysi in 1900 and Branstrom proved the experimental evidence . According to this theory , the dentinal fluid movement on stimulation with chemical , thermal , evaporative or electric stimulus is responsible for excitation of underlying dentinal mechanoreceptors resulting in sensitivity (Alaskar, 2016).

There are various strategies which have been implicated in the treatment of dentine hypersensitivity, including lasers , ions and salts , fluoride iontophoresis , dentine sealers , periodontal soft tissue grafting (Gillam and Koyi, 2020; Salam T A et al., 2023) . However it is still not possible to represent the gold standard technique for the treatment of dentine hypersensitivity . Currently there are two accepted treatment approaches for dentine hypersensitivity 1.) Direct diffusion of depolarising agents such as potassium ions, which reduces intra dental nerve activity 2.) Physical blockage of the open dentinal tubules with occluding agents(Salam T A et al., 2023) . As the newer approaches which include bioactive glasses , strontium , stannous and oxalate salts which forms precipitates over the dentine surface and also within the dentinal tubules , thus reducing the movement of dentinal fluid flow and nerve activation in response to external stimuli .(Maillard et al., 2023)

A clinical study by Pradeep.A et al (2010) concluded that Calcium Sodium Phosphosilicate showed greater reduction in relieving dentine hypersensitivity when compared with potassium nitrate(Gillam, 2015; Soares and Grippo, 2017). CSPS is a bioactive glass which when exposed to body fluids , reacts and has the ability to deposit the mineral content hydroxycarbonate apatite which is similar to that of enamel and dentin. Novamin is a biocompatible bioactive glass used for treating dentin hypersensitivity . Novamin (Calcium sodium phosphosilicate) is a new material of choice , when exposed to body fluids (saliva) which reacts rapidly by releasing mineral ions responsible for the natural remineralization process . It has the ability to deposit hydroxycarbonate apatite and also which reduces the reopening of dentinal tubules (Khijmatgar et al., 2020; Martins et al., 2020). Hydroxycarbonate apatite , a mineral that is chemically similar to the mineral in enamel and dentin . As it is made from the bioactive material which is used in most of the advanced bone regeneration material. The material is safe and non-toxic as it is made with the same minerals which are naturally found in saliva .

The chemical reaction which is initiated by CSPS to promote formation of hydroxy carbonate apatite layer which helps in the treatment of dentin hypersensitivity and also useful for treating demineralized tooth structure (Biria et al., 2021). The material has shown invitro and invivo to occlude dentinal tubules , which is hypothesised to form a strong hydroxy apatite layer on dentin surface thus can resist degradation by repeated acid challenges .Most of the clinical studies have proven that toothpaste with formulations containing CSPS are effective for the treatment of dentin hypersensitivity . The current systematic review presents an overview of the clinical trials pertaining to the effect of various desensitising agents to reduce the dentin hypersensitivity (Khijmatgar et al., 2020).

Our team has extensive knowledge and research experience that has translate into high quality

J Popul Ther Clin Pharmacol Vol 30(14):e91–e101; 12 May 2023.

publications (Neelakantan, Grotra and Sharma, 2013; Mohan and Jagannathan, 2014; Jayaraj et al., 2015; Sheriff, Ahmed Hilal Sheriff and Santhanam, 2018; Dua et al., 2019; Gan et al., 2019; Li et al., 2020; Paramasivam et al., 2020; Aldhuwayhi et al., 2021; Markov et al., 2021)

Aim

The aim of this systematic review is to compare the effectiveness of desensitising agents containing Bioactive glass for the treatment of dentin hypersensitivity .

Research Questions

Is there any difference in the dentifrice which contain bioactive glass and other desensitising agents in the reduction of dentin hypersensitivity ?

Does the dentifrice containing bioactive glass is effective than other desensitising agents in reduction of dentin hypersensitivity ?

Null Hypothesis

There is no difference in the effect of desensitising agents that contain bioactive glass in reducing dentin hypersensitivity.

Alternate Hypothesis

There is a difference in the effect of desensitising agents that contain bioactive glass in reducing dentin hypersensitivity .

MATERIALS AND METHODS

Search Strategy

Five databases, namely PubMed, LILACS, Google Scholar , Science Direct , Scopus were searched on March 15 , 2021 . The mesh terms and keywords were selected and detailed search strategies were adapted for each of the databases. Search strategy aimed to identify all the relevant articles published without restriction of date. Manual search was also conducted by reviewing the reference list of related articles. Search strategies in databases are as follows:

Pubmed (Until 2020)

1. Scopus
2. LILACS
3. The Cochrane library
4. Google scholar (until 2020)

During the electronic database search there were no limits and language restrictions for included studies , all the potential clinical trials relevant to the systematic review has been searched without any time period restrictions . For the identification of randomised clinical trials the reference list of reviews were cross checked for the additional studies that were included .

Eligibility Criteria And Study Selection

The studies which were included according to the eligibility of inclusion criteria , if the studies were randomised , were clinical trials which had intervention and negative groups that had evaluated the effect of DH in adults . The articles are chosen according to the selection criteria of PICO . From the included studies in the final analysis , the following data was extracted : Study name , publication year , country , number of participants included details of the intervention and control groups , follow up period and assessment methods .

Type of studies

Randomised controlled clinical trials that compare the effectiveness of desensitising agents containing Bioactive glass for the treatment of dentin hypersensitivity .

Type of Participants

Patients with age group above 18 years having been diagnosed with dentin hypersensitivity .

Type of Outcome measures

Evaluation of dentin hypersensitivity in response to tactile , thermal and Cold water stimulus .

The inclusion criteria was based on the PICO strategy . Screening of the articles according to the titles and abstracts of the included studies were identified in the electronic database .Articles which were appearing in more than one database were considered only once .Only studies which were meeting the following inclusion criteria were included :

PICO Analysis

Population: Humans with Dentin hypersensitivity
Intervention: Toothpaste containing bioactive glass
Comparison: Toothpaste without bioactive glass
Outcome: To relieve dentin hypersensitivity
Studies: Randomised controlled Clinical trials (RCTs)

Inclusion Criteria

1. All included studies must be RCTs
2. Studies included should have the comparison of bioactive glass with negative control
3.No limitation in the groups included

Exclusion Criteria

1.In vitro studies
2.Animal studies
3.Reviews
4.No control group
5.No relevant outcome variable
6.Unpublished literature without results

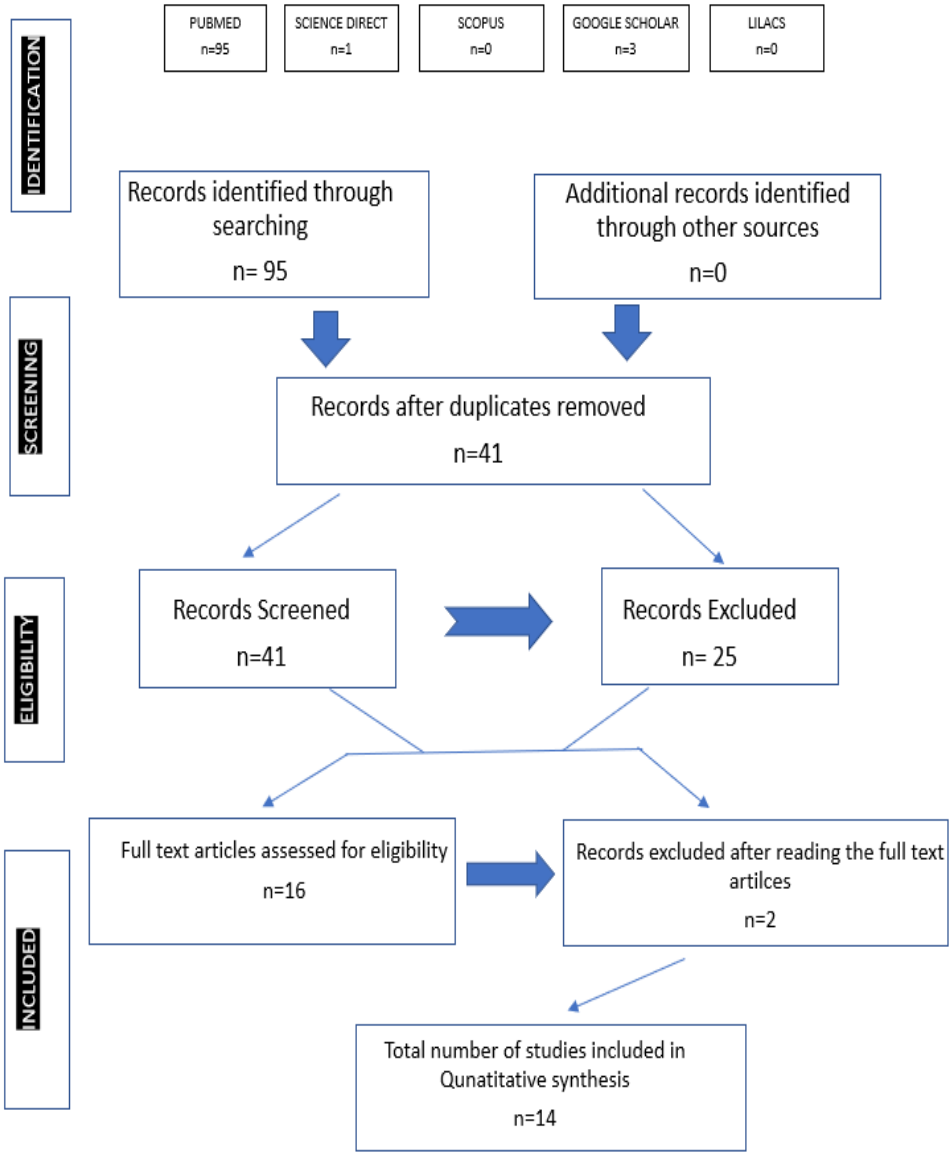


FIG 1: Flow diagram of identification of relevant trials

J Popul Ther Clin Pharmacol Vol 30(14):e91–e101; 12 May 2023.

TABLE 1: Characteristics of included studies

Column	AUTHOR, YEAR, Country	STUDY DESIGN	SAMPLE SIZE	AGE	GROUPS	VARIABLE COMPARED	EVALUATION PERIOD	STATISTICAL TEST DONE	INTERPRETATION
1	YINGYING FU et al; 2019, China	RCT	n=147	18-60 years	Calcium sodium phosphosilicate, 8% Arginine	tactile, thermal air stimuli	1, 2 ,3 and 8 weeks	ANCOVA	CSPS dentifrice showed greater significant reduction in Dentin hypersensitivity when compared to negative control
2	LEONARD LITKOWSKI et al; 2010, USA	RCT	n=66	Not mentioned	2.5% Novamin, 7.5 % Novamin, placebo	tactile, thermal air stimuli	2,4,8 weeks	ONE WAY ANOVA, Duncan's test	Novamin delivered twice daily with dentifrice, has better effect than comparative groups in reducing Dentin hypersensitivity
3	SURYAPRAKASH et al; 2012, INDIA	RCT	n=40	20 - 50 years	7.5% Novamin ,10% strontium chloride	thermal air stimuli, cold water	2, 4, 6 weeks	ANOVA, BONFERRONI POST HOC TEST	Both the test and control group were tested where Novamin tooth paste which showed higher reduction in dentin hypersensitivity, within the intervals of 2, 4 and 6 weeks.
4	SOWMYS SALIAN et al; 2010, India	RCT	n=30	20-50 years	Dentifrice containing 5 % potassium nitrate, Dentifrice containing 5% Novamin, Dentifrice containing no desensitizing agents	tactile, thermal air stimuli, Cold water stimuli	2 weeks, 4 weeks	ANCOVA, Post - Hoc Turkeys analysis	Novamin dentifrice were found to be highly effective in relieving dentin hypersensitivity compared to other groups
5	JEFFERY. L et al; 2012, USA	RCT	n=139	20-40 years	TEST GROUP A - NUPRO Sensodyne prophylaxis paste with 15% Novamin, without fluoride TEST GROUP B - NUPRO Sensodyne prophylaxis paste, 15% Novamin , 2.7% fluoride TEST GROUP C - NUPRO classic without fluoride	tactile, thermal air stimulus	28 days	ANCOVA, Paired -t test	The NUPRO Sensodyne prophylaxis paste with Novamin has shown immediate reduction in dentin hypersensitivity

6	HIRSIGER et al; 2019, Germany, France, Switzerland	RCT	n=273	18-70 years	Test group - Elmex sensitive paste 8% arginine and calcium carbonate without fluoride, Control group - Nupro pumice fluoride free prophylaxis paste	tactile, thermal air stimuli	4, 8, 24 weeks	ANCOVA, Wilcoxon signed rank test, Unpaired t test	The tooth pastes of test group and control group both containing 8% arginine and calcium carbonate achieving instant and sustained relief on dentin hypersensitivity over a follow up period of 24 weeks.
7	ANIRUDH. B et al; 2013, INDIA	RCT	n=20	18-65years	5 % Calcium sodium phosphosilicate, 5% potassium nitrate	thermal air stimuli	2, 4, 8 weeks	ANCOVA, ANOVA, Paired -t test	Calcium phosphosilicate showed greater reduction in Dentin hypersensitivity compared to potassium nitrate
8	PRIYANKA et al; 2016, INDIA	RCT	n=160	20 - 60 years	Group 1 - 5 % potassium nitrate, Group 2 - 5% CSPS with fused silica Group 3 - 10 % Thermoseal Group 34- Herbal tooth paste	tactile, air blast, cold water	2 weeks, 1 month, 2 months	Wilcoxon signed rank test, Kruskal - Wallis test, Mann-Whitney U - test	After 2 months sensitivity values compared with baseline, showed CSPS group shoed significantly better results when compared to either potassium nitrate and herbal dentifrice
9	JOON SEONG et al; 2020, UK	RCT	n= 247	36 years	Calcium sodium phosphosilicate with fluoride, Fluoride tooth paste	thermal air stimuli, tactile	14, 28, 29 days	ANCOVA	The novel fluoride toothpaste containing CSPS is better in reducing DH
10	CLAIRE HALL et al; 2017, UK	RCT	n=135	16 - 60 years	5% CSPS ,8% arginine, negative control	thermal air stimuli, tactile	1, 2, 4, 6, 11 weeks	ANCOVA	Long term of a 5% CSPS occlusion technology -based toothpaste for the relief of DH and indicate similar benefits to those achieved with twice daily use 8 % arginine tooth paste
11	RAJESH K.S et al; 2012, INDIA	RCT	n=30	18-65 years	5% CSPS, Pepsodent paste without desensitizing agent	thermal air stimuli, Cold water test	6, 8 weeks	Unpaired t test, ANOVA	5% Novamin dentifrice had shown the significant decrease in dentin hypersensitivity within 6 and 8 weeks when compared to placebo

12	NEUHAUS et al; 2013	RCT	n=151	18 - 70 years	Test A - 15 % Novamin with	thermal air stimuli	Baseline, 28 days	paired t - Test, ANCOVA	Both fluoridated and non-fluoridated tooth
					2.7 % sodium fluoride, Test B - 15 % Novamin without fluoride, Control - Paste without Novamin and without fluoride				paste which provided significant decrease in the dentin hypersensitivity and has concluded by stating that Group B Novamin provided better reduction than the control groups
13	JOSHI et al; 2020	RCT	n=164	not mentioned	Novamin containing dentifrice	Tactile, thermal air stimuli, cold water stimulus	Baseline, 3, 6 weeks	Chi square test	potassium nitrate and Novamin containing dentifrice were equally effective in reducing dentin hypersensitivity
14	AR. PRADEEP et al; 2010, INDIA	RCT	n=110	20-60 years	5% calcium sodium phosphosilicate with fused silica, 5% potassium nitrate as positive control, tooth paste containing the same formulation as calcium sodium phosphosilicate except active ingredient	Thermal air stimuli, cold water stimulus	2, 6 weeks	Post hoc, ANOVA	The calcium sodium phosphosilicate group showed better reduction in dentin hypersensitivity in both tactile and cold-water stimuli. (Potassium nitrate and placebo groups compared)

Description Of Included Studies

Detailed data from 14 included studies are listed in Table 1 . All included studies were RCTs comparing CSPS with a negative control group .CSPS was applied in the form of self administered toothpaste or professionally applied prophylaxis paste used with different concentrations . The evaluation period ranged from 7 days to 2 years . Dentin hypersensitivity was elicited by tactile , evaporative or thermal stimuli in all the 14 studies included . Different scales were used to quantify DH ,Visual analogue scale (VAS) was the most commonly used for the measurements of Dentin hypersensitivity **.**

Risk Of Bias Assessment

The risk of bias was done based on the Cochrane collaboration tool for risk assessment as follows ; Random sequence generation , allocation concealment , blinding of participants and personnel , blinding of outcome assessment , incomplete outcome data , selective reporting bias and other sources of bias . Differences which were resolved through discussion included studies some of the studies had low risk of bias where some other studies had high risk of bias . Evaluation of the included studies shown in figure 2 .

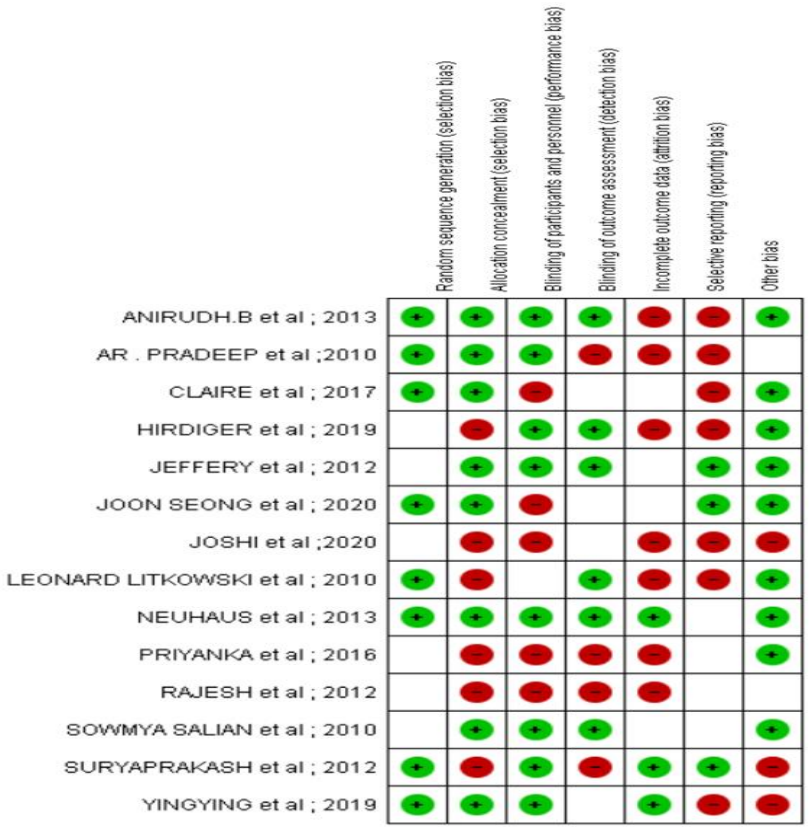
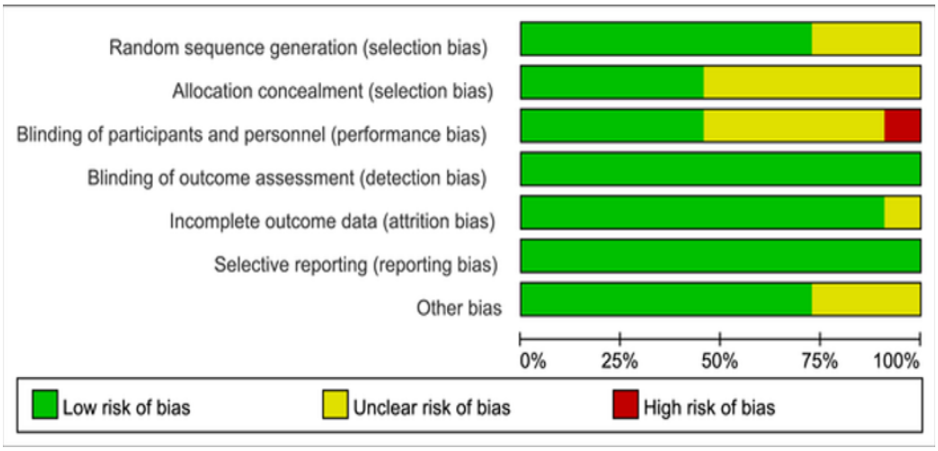


FIG 2: Risk of bias assessment



DISCUSSION

The purpose of this systematic review was to evaluate the effect of bioactive glass [CSPS] containing dentifrice on the reduction of dentin hypersensitivity. Thirteen studies fulfilled the criteria for being included in the review. According to the included studies, 3 studies had similar experimental toothpastes containing 5% bioactive glass (Salian et al 2010, Pradeep et al 2010, Rajesh et al 2011) , whereas in remaining studies experimental groups 2.5, 5.5 & 7.5% concentrations of bioactive glass were used. Clinical trials included in this systematic review evaluated the reduction in dentin hypersensitivity in patients treated with bioactive glass dentifrice by application of a thermal air stimulus (Salian et

al 2010; Litkowski et al 2010; Pradeep et al 2010) . Tactile and air blast stimuli were performed in 13 included studies, whereas variable (Cold water stimuli) was used for evaluation in 6 studies (Suryaprakash et al 2012; Sowmya et al 2010; Priyanka et al 2016 ; Rajesh et al 2012 ; Joshi et al 2020 ; Pradeep et al 2010) .Combination of tactile and thermal stimuli were evaluated in 6 studies (Yingying et al 2019, Litkowski et al 2010 ; Joon seong et al 2020 ; Claire Hall at al 2017 ; Anirudh et al 2013 ; Neuhaus et al 2013) . In 11 included studies the mean age group of participants was 18-50 years whereas two studies did not mention the age criteria (Litkowski et al 2010 & Joshi et al 2020) . Among the 14 included studies, bioactive glass containing toothpaste were significantly better desensitizing agents in 12 included studies, whereas 2 studies showed no significant difference between the desensitizing pastes used based on the follow up of baseline to 8 weeks (Yingying et al 2019 ; Joshi et al 2020) . The effectiveness of CSPS was higher in 7 included studies and one study did not find any significant difference between the desensitising agents (Yingying et al 2019) .In the included studies three different dentin hypersensitivity evaluation methods were used . In 8 studies dentin hypersensitivity was assessed by VAS (Litkowski et al 2010; Suryaprakash et al 2012; Sowmya et al 2010; Anirudh et al 2013; Priyanka et al 102016; Rajesh et al 2012; A.R Pradeep et al 2013; Claire Hall et al 2017), in 4 studies dentin hypersensitivity was assessed by NRS [Numeric Rating scale] (Yingying et al 2019; Jefferey et al 2012; Joon seong et al 2020; Neuhaus et al 2013) and 1 study by VRS (Joshi et al 2020) . According to the included studies, continuous use of dentifrice containing CSPS had significantly shown reduction in dentin hypersensitivity when compared with the placebo. The follow up period less than four weeks had given better results in reduction of dentin hypersensitivity.

Bioactive glass when incorporated in dentifrice, CSPS particles deposited on the dentin surface tends to occlude the dentinal tubules mechanically. Physical occlusion of bioactive glass begins when the material is in aqueous environment. Series of reactions occur initially within seconds when exposed to saliva, release of calcium and phosphate ions continue as long as the particles are exposed to aqueous environment . Hence there is transient increase in the oral pH during the initial exposure of material due to release of sodium.(Sufi et al., 2016) Increase in pH helps in precipitation of calcium and phosphate ions from the particles of bioactive glass along with calcium and phosphorus found in saliva to form calcium phosphate layer.(Earl et al., 2011) As the particle reaction continues, the deposition of calcium and phosphate complexes continues, this layer crystallises into hydroxycarbonate apatite, which chemically equivalent to biological apatite. Hence the combined action of bioactive glass particles and hydroxycarbonate apatite layer results in physical occlusion of dentinal tubules, which reduces dentin hypersensitivity (Earl et al., 2011)

Among the thirteen included studies for detailed review the level of evidence was high in three studies (Jeffery et al, Neuhaus et al , Sowmya Salian et al) ,2 studies had moderate level of evidence (Yingying et al , Joon seong et al) and other 9 studies had low level of evidence. . In future, the high quality and long term follow up studies in this field should be conducted for clinical implication in the treatment of dentin hypersensitivity as it is a prospective subject in the field of endodontics.

CONCLUSION

According to the 13 (RCT's) included studies in this systematic review , the bioactive glass containing dentifrice had superior reduction of dentin hypersensitivity compared to dentifrice without bioactive glass .

CONFLICT OF INTEREST

Authors declare by stating that they have no conflict of interest .

FUNDING

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