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Original Research

Comparative Evaluation of Zinc Carbonate–Hydroxyapatite and a Light-Cured Desensitizing Agent (Shield Force Plus) on Reduction of Postoperative Sensitivity Following Direct Composite Restorations: A Randomized Controlled Clinical Trial

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ABSTRACT:

Introduction: Postoperative sensitivity (POS) is a frequent complaint after direct composite restorations. Biomimetic zinc-carbonate–substituted hydroxyapatite (Zn-CHA) and light-cured desensitizers such as Shield Force Plus (SFP) are used chairside to occlude dentinal tubules and stabilize fluid dynamics. Comparative clinical evidence remains limited. **Methods:** Adult patients with vital posterior teeth indicated for Class I resin composite restoration were recruited. Following standardized cavity preparation and adhesive protocol, teeth were randomly assigned to: Group 1-control group (Self etch) Group 2-control group (selective etch) • Group 3 test group Zn CHA (Self etch) • Group 4 test group Zn CHA (selective etch) • Group 5 test group Shield Force Plus Desensitizer (Self etch) • Group 6 test group Shield Force Plus Desensitizer (selective etch). POS was assessed using 10-cm visual analog scale (VAS) The participants were recalled at 1 week, 1 month for post operative sensitivity and evaluation was done using airblast technique and use of cold water. **Results:** There was significant difference found between control group and test group in postoperative sensitivity at one week interval but after one month except zinc carbonate hydroxyapatite other group show no significant difference in postoperative sensitivity. In comparison to shield force plus desensitizer, significant difference was found with zinc carbonate hydroxyapatite at 1 week interval. However, at 1 month interval no significant difference between the two was present. **Conclusion:** The study concluded that both desensitizers used successfully decreased dentin hypersensitivity within the constraints of the study. Zinc Hydroxyapatite is more efficient compared to Shield Force Plus at all-time points irrespective of the stimuli over a 1-month follow-up, thereby demonstrating Zn-CHA as a novel agent to repair and remineralize dental hard tissues.

Keywords: postoperative sensitivity; composite restoration; desensitizer; zinc-carbonate hydroxyapatite; Shield Force Plus;

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INTRODUCTION

Dentinal hypersensitivity (DH) is a common dental condition characterized by transient, sharp pain in response to stimuli such as cold, heat, or touch. The aetiology of postoperative sensitivity is multifactorial, encompassing microleakage, polymerization shrinkage, and unsealed dentinal tubules. Addressing this issue is crucial to enhancing patient comfort and satisfaction. [1]

It was reported that postoperative sensitivity following adhesive resin restorations could be related to mechanical trauma and microleakage of bacteria.[2] Other studies reported that polymerization shrinkage of composite resins forms a major problem and limits its advantages such as, debonding, and gap formation between the composite resin and tooth, leading to the deformation of restorations under occlusal stresses which transmits hydraulic pressure to the odontoblastic processes causing pain.[3]

Several strategies published in the literature tried to solve the problem of postoperative sensitivity, by using different light-curing modes, different adhesive strategies, applying desensitizers, and implementing different techniques for placement of posterior composite restorations.[4,5]

Different adhesive systems are namely total etch, selective etch, self-etch system. Which can be successfully used in both enamel and dentin. Newer self-etch (SE) adhesive systems simultaneously etch, infiltrate, and polymerize to seal the prepared dentin. [6]

The application of dental desensitizing agents is one of the most preferred methods to prevent dental hypersensitivity. Zinc Carbonate Hydroxyapatite (Zn CHA) and Shield Force Plus have gained attention due to their unique properties and mechanisms of action.[7]

The properties of Zinc Carbonate Hydroxyapatite allow it to integrate well with the tooth structure, facilitating remineralization and enhancing the long-term durability of the restoration. This bioactive material has also been shown to have antibacterial properties, potentially contributing to the prevention of secondary caries[8].

On the other hand, Shield Force Plus provides immediate relief by forming a durable resin coating, which effectively seals the dentinal tubules while maintaining compatibility with composite bonding systems. These distinct modes of action make both agents attractive options for managing postoperative sensitivity.[9,10]

Comparative studies investigating the efficacy of different desensitizing agents under clinical conditions are limited, leaving practitioners to rely on anecdotal evidence or manufacturer claims. Therefore, this study seeks to address this gap by evaluating and comparing the performance of Zinc Carbonate Hydroxyapatite and Shield Force Plus in an in-vivo setting.

MATERIALS AND METHODS

The study was approved by the Institutional Ethics Committee – EC/PG-12/2023. Written informed consent obtained from all participants. The study included permanent Mandibular first and second molar with vital pulp having mild and moderate occlusal caries with patients mean age range from 20–45 years.Teeth which were previously restored and compromised periodontal status and participants presenting with spontaneous or orofacial pain were excluded.

Study was carried out in 120 patients requiring class I composite restoration in first and second mandibular molars divided into 6 groups consist of 20 participants each. All the practical evaluations were performed by a single investigator, who was blinded and was not informed about the group assignment.

Isolation of operating field is maintained with the application of rubber dam and conventional Class I cavity preparation was done using small round bur with a high-speed airotor handpiece and a caries detection dye was also used to determine the extent of caries. Participants were then subjected to the randomization procedure and allocated to one of the treatment options.

Group 1-control group (Self etch)

After cavity preparation, the pulpal floor was coated with (EDTA) solution (Prime Dental Products PVT. LTD) and after 2 min, the solution was washed away.The entire cavity was then coated with SE Bonding agent single bond universal (3M ESPE) and scrubbed for 10 s and then the excess was removed and light-cured according to the manufacturer's instructions.The cavity was restored with Nanohybrid composite (3M ESPE Filtek Z 350 XT)

Group 2-control group (selective etch)

After cavity preparation, the pulpal floor was coated with (EDTA) solution (Prime Dental Products PVT. LTD) and after 2 min, the solution was washed away. 37% phosphoric acid was applied to cavosurface margin and after 10 s, the etchant was applied to the remaining cavity. Within 5 s, the cavity was washed thoroughly with water for 1 min. The entire cavity was gently air-dried to remove the surface moisture and then coated with a bonding agent. After 10 s, the excess was removed and light-cured according to the manufacturer's instructions.The cavity was restored with Nanohybrid composite (3M ESPE Filtek Z 350 XT)

Group 3 test group Zn CHA (Self etch)

After cavity preparation, the pulpal floor was coated with (EDTA) solution (Prime Dental Products PVT. LTD), and after 2 min, the solution was washed away. Later, the remineralizing agent, Zn CHA (Bio repair, Stomysens), was applied to the pulpal floor with an applicator tip. After 5 min, the cavity was gently air-dried using a dental unit air syringe to remove the excess agent. The self etch technique was followed in this group Then The cavity was restored with Nanohybrid composite (3M ESPE Filtek Z 350 XT)

Group 4 test group Zn CHA (Selective etch)

After cavity preparation, the pulpal floor was coated with EDTA solution, and after 2 min, the solution was washed away. Later the Zn-CHA, was applied to the pulpal floor with an applicator tip. After 5 min, the cavity was gently air-dried using a dental unit air syringe to remove the excess agent. The selective-etch technique was followed in this group. After selective etch, the entire cavity was gently air-dried to remove the surface moisture and then the entire cavity was then coated with SE Bonding agent single bond universal (3M ESPE) and light-cured according to the manufacturer's instructions. The cavity was restored with Nanohybrid composite (3M ESPE Filtek Z 350 XT)

Group 5 test group Shield Force Plus Desensitizer (Self etch)

After cavity preparation, the pulpal floor was coated with (EDTA) solution (Prime Dental Products PVT. LTD), and after 2 min, the solution was washed away. Later, the, Shield Force Plus was applied to the pulpal floor with an applicator tip. After 5 min, the cavity was gently air-dried using a dental unit air syringe to remove the excess agent and light cured. The self-etch technique was followed in this group.Thenthe cavity was restored with Nanohybrid composite (3M ESPE Filtek Z 350 XT)

Group 6- test group Shield Force Plus Desensitizer (Selective etch)

After cavity preparation, the pulpal floor was coated with EDTA solution, and after 2 min, the solution was washed away. The selective-etch technique was followed in this group. The entire cavity was gently air-dried to remove the surface moisture and Shield Force Plus, was applied to the pulpal floor with an applicator tip. After 5 min, the cavity was gently air-dried and light cured. Then the entire cavity was then coated with SE Bonding agent single bond universal (3M ESPE) and then the excess was removed and light-cured according to the manufacturer's instructions. The cavity was restored with Nanohybrid composite (3M ESPE Filtek Z 350 XT)

In all the above-mentioned groups, the finishing of the restoration was done using flame-shaped diamond-finishing burs (Shofu). Premature contacts were evaluated in both centric and eccentric by asking the participant to close lightly on a piece of articulating paper (Prodent) with the participants seated and the occlusal plane parallel to the ground.

The participants were recalled at 1 week, 1 month for evaluation.There were no loses to follow-up during the trial period. The sensitivity was checked by Airblast stimulation and cold test.For both the methods VAS was given to the participants and asked to mark at a point on a linear scale marked from 0 to 10 to describe the pain experienced ranging from no pain to worst unimaginable pain.

Statistical analysis

Statistical analysis was carried out to participants who fulfilled the protocol in terms of eligibility, intervention, and outcome assessment.The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation. The inter group comparison was doneusing One Way ANOVA to find the difference between groups. The intragroup comparison between the time intervals was done using the Paired t test /Wilcoxon Sign Rank test The ordinal variables were compared using the Chi Square test The level of the significance for the present study was fixed at 5%. The Shapiro–W ilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables.

RESULT

Table 1- Intragroup comparison of mean sensitivity scores between different time intervals

	Pre Op	1 Week	1 Month	P value
Group 1	4.25 ± 1.25	2.40 ± 1.05	0.45 ± 0.76	0.001{Significant}
Group 2	3.85 ± 1.96	2.35 ± 1.60	0.50 ± 0.69	0.001{Significant}
Group 3	3.85 ± 2.06	0.15 ± 0.37	0.00 ± 0.00	0.001{Significant}
Group 4	3.65 ± 2.04	0.25 ± 0.44	0.00 ± 0.00	0.001{Significant}
Group 5	3.80 ± 0.95	1.30 ± 0.66	0.25 ± 0.44	0.001{Significant}
Group 6	3.80 ± 0.95	2.25 ± 0.79	0.25 ± 0.44	0.001{Significant}

Table 2- Post hoc Intragroup comparison of mean sensitivity scores between different time intervals

	Comparison	Mean Difference	Std. Error	p-value	Significance
Group 1	Pre Op vs 1 Week	1.85	0.40	0.001	Significant
	Pre Op vs 1 Month	3.80	0.40	0.001	Significant
	1 Week vs 1 Month	1.95	0.40	0.001	Significant
Group 2	Pre Op vs 1 Week	1.50	0.50	0.001	Significant
	Pre Op vs 1 Month	3.35	0.50	0.001	Significant
	1 Week vs 1 Month	1.85	0.50	0.001	Significant
Group 3	Pre Op vs 1 Week	3.70	0.50	0.001	Significant
	Pre Op vs 1 Month	3.85	0.50	0.001	Significant
	1 Week vs 1 Month	0.15	0.50	0.720	Non-Significant
Group 4	Pre Op vs 1 Week	3.40	0.50	0.001	Significant
	Pre Op vs 1 Month	3.65	0.50	0.001	Significant
	1 Week vs 1 Month	0.25	0.50	0.720	Non-Significant
Group 5	Pre Op vs 1 Week	2.50	0.50	0.001	Significant
	Pre Op vs 1 Month	3.55	0.50	0.001	Significant
	1 Week vs 1 Month	1.05	0.50	0.001	Significant

Group 6	Pre Op vs 1 Week	1.55	0.50	0.001	Significant
	Pre Op vs 1 Month	3.55	0.50	0.001	Significant
	1 Week vs 1 Month	2.00	0.50	0.001	Significant

The intragroup comparison of mean sensitivity scores across different time intervals (Pre Op, 1 Week, and 1 Month) showed significant changes in sensitivity for all groups. In Group 1 (Self-etch without desensitizer), there was a substantial decrease in sensitivity from Pre Op to 1 Week and further significant reduction from Pre Op to1 Month. Sensitivity continued to decline between 1 Week and 1 Month as well. Similarly, Group 2 (Selective etch without desensitizer) showed significant reductions from Pre Op to 1 Week and from Pre Op to 1 Month, with a notable decrease between 1 Week and 1 Month (Table 1 & 2).

In Group 3, the decrease in sensitivity from Pre Op to 1 Week was significant and there was continued improvement from Pre Op to 1 Month. However, the comparison between1 Week and 1 Month was not significant, suggesting that sensitivity had stabilized after 1 Week. Group 4 (Zn CHA Selective etch) also demonstrated significant sensitivity reduction from Pre Op to 1 Week and from Pre Op to 1 Month. Yet, the change from 1 Week to 1 Month was not significant indicating a similar stabilization effect. Group 5 (Shield Force Plus Self-etch)showed a marked decrease in sensitivity from Pre Op to 1 Week and from Pre Op to 1 Month with a significant reduction also observed between 1 Week and 1 Month (Table 1 & 2).

Lastly, Group 6 (Shield Force Plus Selective etch) displayed a significant decrease in sensitivity from Pre Op to 1 Week and from Pre Op to 1 Month with a substantial reduction between 1 Week and 1 Month. Overall, the results indicate that all groups experienced significant reductions in sensitivity over time, particularly between Pre Op and 1 Week and between Pre Op and 1 Month. However, after the 1-week mark, some groups, especially Group 3 (Zn CHA Self-etch) and Group 4 (Zn CHA Selective etch), showed no further significant improvement, suggesting a stabilization of sensitivity (Table 1 & 2).

DISCUSSION

With the advent of newer techniques and concepts in adhesive dentistry, there has been an increase in the frequency of replacing amalgam restorations with direct composite restorations due to esthetics and health issues.[11]However, the associated complications of composite restorations are yet to be solved, such as marginal discoloration and postoperative sensitivity, which directly attribute to polymerization shrinkage and related stress at the restoration–tooth-bonded interface. [12]

The postulated theory for postoperative sensitivity following composite restorations includes gap formation which predisposes to microleakage. Microleakage, in turn, causes compression of the restoration during loading,.Therefore, the current theory of pulpal tooth pain dictates that any change in the hydraulic pressure within the dentinal tubules stimulates the pain receptors within the pulp, thereby causing pain.[8]

Several strategies published in the literature tried to solve the problem of postoperative sensitivity, by using different light-curing modes.[4]different adhesive strategies,[13] applying desensitizers, cavity disinfectants before the bonding procedure.[14] and implementing different techniques for placement of posterior composite restorations.[5].

The basic principles for the prevention of dentin sensitivity are blocking the dentinal tubules or chemically blocking the pulpal nerve. Cumin et al fount that A toothpaste containing 8% arginine, 1450 ppm fluoride, and calcium carbonate (sodium Mon fluorophosphate) is effective in reducing dentin sensitivity compared to 2% potassium ions toothpaste. [15]The arginine containing toothpaste seals dentin tubules with a plug that contains arginine, calcium carbonate, and sodium phosphate, arginine is positively charged and bind to the dentin surface, which is negatively charged, and attract calcium from the saliva to block the dentinal tubules.

Resin-based materials are also reported to reduce dentin hypersensitivity effectively. A solution of glutaraldehyde and hydroxyethyl methacrylate (HEMA) has also been shown to be effective for up to 9 months due to the occlusion of tubule by glutaraldehyde.[16] Oxalates are also effective causing the formation of oxalate precipitation, Other modern treatments include thin coatings, adhesive resins, topically applied agents, and lasers.[17]

Thus, the present study aimed to compare the reduction in postoperative sensitivity following class 1 composite restoration using zinc carbonate hydroxyapatite and Shield force plus desensitizer.

Zinc Carbonate Hydroxyapatite is biocompatible and bioactive, mimicking the natural mineral composition of dentin and promoting effective tubule occlusion ,Zn CHA nanocrystals used which led to remineralization/repair of the surface by deposition of a hydroxyapatite-rich coating. Concerning its nano-sized bioactive components, those gaps in the dentinal tubules could be sealed completely with plugs within a few minutes until the regeneration of a mineralized layer has occurred within a few hours. Besides, its high surface area permits the release of more calcium and phosphate ions at low concentrations.

The mechanism of hypersensitive dentin treatment of TOKUYAMA SHIELD FORCE PLUS is believed to be based on the double-block effect. When itis applied to the affected area, the adhesive monomer (3D-SR monomer) and calcium in the tooth substance react, and the reaction product accumulate in the

dentinal tubules and on the coated surface. When the solvent component and water are removed with a stream of air, a thin film forms on the surface affected by hypersensitivity. At this stage, the dentinal tubules are sealed, and the treatment effect (pain relief) appears. Exposure to light cures the reaction product in the dentinal tubules and the thin film on the coated surface, forming a strong coating.[18,19]

In the present trial, participants aged between 20 and 45 were considered; this is because dentin is neither too young nor old and has a good remineralizing potential. Smear Clear (17% EDTA) was used to disturb the smear layer and make the surface active for dentin remineralization. [20]

In order to minimize variation in the restorative technique in the current study, all the restorative procedures were carried out by a single operator. Furthermore, in order to avoid bias in the distribution of tooth type, mandibular 1st and 2nd molars were considered in the present study.

Class I cavities were considered in the present trial because of the higher incidence of reported post operative sensitivity in the literature, which could be attributed the configuration factor or C factor. In Class I cavities, the C factor is the highest (5/1); therefore, the higher the C factor, the higher is the stress resulting from polymerization shrinkage[21]. The VAS method was used to evaluate POS in the current study. This offers participants a wider range of responses and more uniform instructions by avoiding descriptors such as mild, moderate, and severe, which can be interpreted quite differently from one participant to another. It also provides a more accurate and effective statistical test than other tests based on the fixed categories. [22]

According to the previous study by Yousaf et al., postoperative sensitivity was typically reported by the patients during the 1st week after the restorative procedure with a reduction in incidence over a period of time.[23] Therefore, in order to minimize recall bias in the current study, the re-evaluation was done at baseline, after 1 week,1 month. In this study, six groups were divided on basis of different adhesive technique (self-etch and selective etch) and the different desensitizing agent i.e. Shield force plus and zinc carbonate hydroxyapatite, sensitivity was evaluated at the 1-week and 1month time interval.

The results of the post hoc comparisons for mean sensitivity scores at the 1week follow-up revealed several significant differences between the groups. Group 1 (self-etch without desensitizer) and Group 2 (selective etch without desensitizer) exhibited significantly higher sensitivity scores compared to Groups 3, 4, and 5, 6 with mean differences of 2.250, 2.150, and 1.100, 0.9respectively. The analysis highlights significant differences in sensitivity between various etching and desensitizing treatments at the 1-week follow-up, with self-etch and selective etch groups demonstrating notably higher scores compared to the Zn CHA groups and shield force plus treatments

Simlilarly ,at 1month follow up group 1and 2 reported higher postoperative sensitivity score compared to other groups. And group 3and 4 showing significantly lower score compare to group 1,2,5,6. At all time interval intragroup comparison in group 1 and 2, 3and 4, 5and6 showed no significant difference indicated that different adhesive technique does not affect the postoperative sensitivity. The result are similar to the study by Francis et al. showed that there was no significant difference in postoperative sensitivity between total-etch and selective-etch techniques at baseline, immediately after treatment, 24 h, and 2 weeks after treatment.

Intragroup comparison Between group 1 and 2, group 1 (self-etch) revealed less postoperative sensitivity than selective etch at all time this can be attributed to the fact that the self-etching adhesive primers create thin hybrid layers that incorporate the smear layer. They demineralize the smear layer and incorporate its remnants into a mixture of collagen fibers and resin monomers after which the smear layer becomes an integral part of the hybrid layer minimizing the occurrence of postoperative sensitivity.[6]

Group 3 and 4 showing less postoperative sensitivity compare to other group at all time interval this might be because of Zn-CHA nanocrystals were used which led to remineralization/repair of the surface by deposition of a hydroxyapatite-rich coating.[7]

Study by A.V Rai et al. shown similar result of reduction of postoperative sensitivity in Class I restoration using self -etch or selective etch with or without zinc carbonate hydroxyapatite. [24].The study by Orsini et al. shown that Zn-CHA toothpaste significantly reduce dentin hypersensitivity after 4 and 8 weeks, supporting its utility in clinical practice.[25]

Group 5 and 6 used shield force plus technique and showed reduction in postoperative sensitivity at all time interval but in comparison to group 3 and 4 the reduction in post operative sensitivity is at lower level. this may be due to the fact that shield force plus form thin mechanical barrier which do not integrate with dentin structure resulting in removal of protective barrier with time and there is lack of self remineralising capability. Similar study by Yelloji Paramesh et al. revealed Clinpro XT Varnish (resin-modified glass ionomer-based varnish with silane-treated glass) is more efficient compared to Shield Force Plus at all-time points irrespective of the stimuli after a 1-month follow-up.[13]

The present trial has a few limitations as it involved restoration of mild to moderate caries thus result can't be generalized as in case of deep caries the dentin is prepared closer to the pulp, the tubule density, and diameter increase, thus increasing both the volume and flow of pulpal fluid (hydrodynamic effects) . Therefore, moderate-to deep cavities should be compared for further evaluation. Also, specific cavity design (Class I Cavity) was involved in the present

study thus, future trials are required for evaluating the effect of desensitizers on Class 2 Carious lesions. And a relatively shorter follow-up. Therefore, further long term follow-up studies should be conducted to assess the other clinical parameters such as microleakage, bonding strength etc. before recommending their routine application in dentistry.

CONCLUSION

The study concluded that both desensitizers used aresuccessfully decreased dentin hypersensitivity within the constraints of the study. Zinc Hydroxyapatite is more efficient compared to Shield Force Plus at all-time points irrespective of the stimuli over a 1-month follow-up, thereby demonstrating Zn-CHA as a novel agent to repair and remineralize dental hard tissues

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Research Ethics Committee (RUHS-CDSEC/PG-12/2023)

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Conflicts of Interest: The authors declare no conflict of interest.

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