International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s,2025
https://theaspd.com/index.php

Comparative Evaluation Of Efficacy Of Milk Proteins, Calcium Containing Silicates And Carbonates And Fluoride Containing Toothpaste As Desensitizing Agents – A SEM Study

Anisha Sukhija[1], Mehtab Singh Kamal[2], Ananya Modgil[3], Shridul Gupta[4], Aakash Suman[5], Apurva[6]
[1]Intern, Department of Periodontology and Oral Implantology, Genesis Institute of Dental Sciences and Research
[2]PG Department of Periodontology and Oral Implantology, Genesis Institute of Dental Sciences and Research
[3]Intern, Department of Periodontology and Oral Implantology, Genesis Institute of Dental Sciences and Research
[4]PG Department of Periodontology and Oral Implantology, Genesis Institute of Dental Sciences and Research
[5]Department of Periodontology and Oral Implantology, Genesis Institute of Dental Sciences and Research
[6]Department of Periodontology and Oral Implantology, Genesis Institute of Dental Sciences and Research

Abstract
Background: Pain/discomfort in the areas of exposed dentin in response to stimuli present a common yet multifaceted challenge in the field of dentistry. This condition, referred to as dentinal hypersensitivity, affects a significant portion of the adult population and can considerably alter the quality of life of the patient. Therefore, it is vital to analyze and evaluate the potential treatment modalities for improving the overall patient health.
Aim/objective: *To evaluate the efficacy of milk proteins, biodentine and fluoride containing toothpaste as desensitizing agents in the areas of exposed dentin of samples in vitro.*
Methods: *A total of 60 longitudinal sections of periodontal compromised extracted teeth were taken. Each sample underwent acid etching in the area of CEJ. These were then segregated into 3 groups of 20 samples each, followed by the application of milk proteins, biodentine and fluoride containing toothpaste respectively. A comparative analysis of their grain size was made under a scanning electron microscope.*
Results: *The grain size of the samples treated with milk proteins was found to be 1.46 +/- 0.11, followed by 1.90 +/- 0.12 in samples of biodentine and 3.02 +/- 0.38 in the samples of sensodyne in micrometers.*
Conclusion: *All the above mentioned materials were found to be effective desensitizing agents. The milk proteins being the most effective followed by biodentine and fluoride containing toothpaste, respectively.*
Keywords: *Dentinal hypersensitivity, scanning electron microscope, Desensitizing Agents.*

INTRODUCTION

Dentinal hypersensitivity is a common problem faced by individuals typically in the second to sixth decade of adult life.(1) With a multifactorial etiology, it is clinically observed as acute pain stemming from disturbance in the A Delta nerve fibers of the dentin and their tubules due to chemical, thermal, osmotic, evaporative or tactile triggers.(3) Dentin hypersensitivity manifests as pain or as an increased sensitivity in the dentin.(4) Five distinct mechanisms have been suggested to account for dentinal sensitivity: the classic hydrodynamic theory, which involves fluid movement in the tubules; direct innervation of the dentinal tubules; neuroplasticity and the sensitization of nociceptors; odontoblasts functioning as sensory receptors; and algoneurons, which are involved in pain transmission.The hydrodynamic theory by Brannstrom et al explains the mechanism of dentinal hypersensitivity.(5) It explains the movement of the fluid present in the dentinal tubules in response to a stimulus. The fluid movement creates pressure in the surrounding neurons, thereby causing hypersensitivity or pain.(6) Current treatments modalities based on this theory, aim to occlude open dentinal tubules either partially or completely and inhibit the activity of dentinal neurons. As the sensitivity sets in, the pulp becomes susceptible to irritation, suggesting a need to address not only dentinal permeability but also the neural component.(7) Various treatments including cavity varnishes, calcium compounds, fluoride based interventions and lasers have been attempted to alleviate dentinal hypersensitivity.(8) However, while effective in relieving dentinal hypersensitivity they present challenges since dentinal tubules are fragile against tooth erosion and abrasion.(9) The primary challenge remains finding a biocompatible material that prevents pain with prolonged results.(10)Among professionally employed treatment modalities, CPP-ACP i.e., Casein phosphopeptide–amorphous calcium phosphate complexes are used in patients with dentinal hypersensitivity.(11) CPP-ACP is a calcium and phosphate based remineralising agent present in GC Tooth Mousse. It works by forming mineral precipitates containing appetite by infusing calcium and phosphate ions in the tooth surfaces with pellicle and plaque.(12)However, the fluoride containing toothpaste viz., Sensodyne, Colgate sensitive pro relief, etc which has fluoride ions as its main ingredient forms a compound called fluorapatite which is more resistant to sensitivity than the naturally occurring hydroxyapatite.Whereas, biodentine contains tricalcium silicate and calcium carbonate which possess desensitizing properties.(13) The mechanism of action involves the hydration process of calcium silicate based cement thereby releasing calcium hydroxide, leading to the formation of biological appetite in the presence of phosphate containing fluids.(14)Therefore, our study aims to assess and compare the efficacy of various desensitizing agents in reducing dentinal hypersensitivity using scanning electron microscope in samples in vitro. The scanning electron microscope shows highly magnified images of dentinal tubules of the samples being studied. The grain size in the SEM analysis is evaluated to check for the efficacy of the materials used. The greater the grain size, lesser the occlusion of the dentinal tubules hence, lesser is the efficacy of the material used. Therefore, a comparative analysis is crucial to determine their capacity to seal the dentinal tubules effectively and vital in improving the overall health of the patient.

MATERIALS AND METHODS

The approval of the ethics committee of the institution was taken before the beginning of the study. A total number of 60 periodontally compromised, extracted teeth were collected followed by the longitudinal sectioning of each tooth sample according to the protocols set by the ethics committee of the institution.The mounting of each sample was done on a metal stub or holder. These samples then underwent acid etching by 37% phosphoric acid gel, followed by distilled water rinse and drying. These 60 samples were then segregated into three categories of 20 samples each followed by the application of the materials with the help of a cotton pellet in a brushing stroke action. A small amount of Calcium containing silicates and carbonates (biodentine^{R}) was mixed with one drop of its liquid counterpart and applied on the first 20 samples successively. The material was then left undisturbed for 12 minutes in order to set. This was followed by the application of Casein phosphopeptide–amorphous calcium phosphate complexes (GC Tooth Mousse^{R}) the next 20 samples, each of which was then washed after a 3 minutes application and air dried. The fluoride containing toothpaste (sensodyne^{R}) was applied on the remaining samples for 10 minutes and then washed and air dried.Each of these samples was then studied with the help of a scanning electron microscope. The magnification was set on 5.00 K X for all the samples under study.

RESULTS

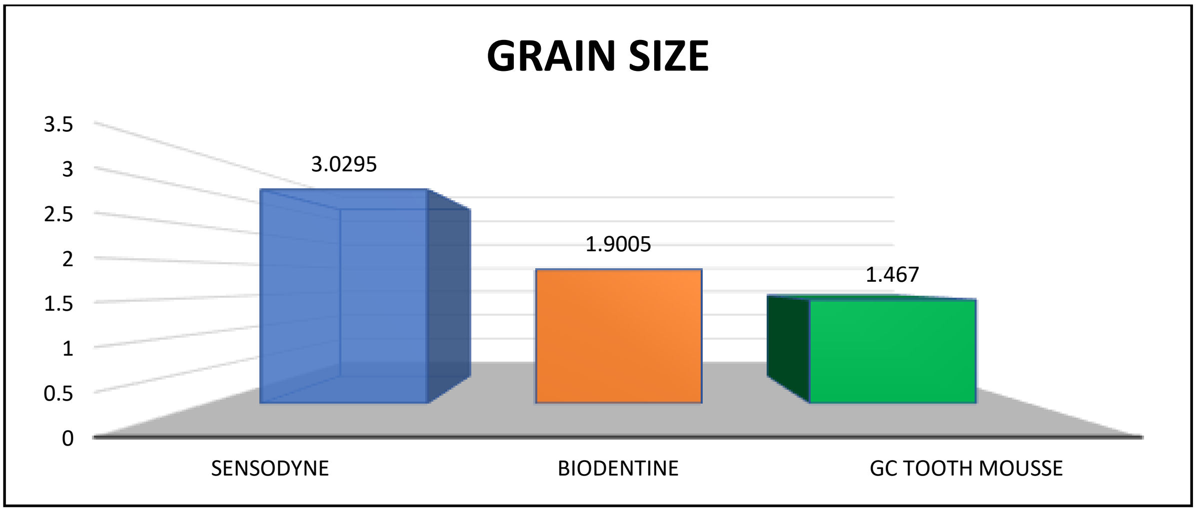
All the materials used in this study showed a decrease in the number as well as the grain size of the samples as studied under SEM. The results were as follows -

In terms of the grain size seen in the scanning electron microscope images - the smallest of grain size was seen in the samples of Casein phosphopeptide–amorphous calcium phosphate complexes with the mean value as 1.46+/- 0.17, followed by 1.90 +/- 0.12 in samples of Calcium containing silicates and carbonates and 3.02 +/- 0.38 in samples of fluoride containing toothpaste, respectively.

Table 1: Comparative Evaluation of Efficacy of Milk Proteins, Biodentine, Fluoride Containing Toothpaste

	N	Mean		95% Confidence Interval for Mean	Minimum	Maximum	

			Std. Deviation	Lower Bound	Upper Bound			P value
SENSODYNE	20	3.0295	.38802	2.8479	3.2111	2.18	3.65	0.001*, sig
BIODENTINE	20	1.9005	.12580	1.8416	1.9594	1.65	2.05	
GC TOOTH MOUSSE	20	1.4670	.17226	1.3864	1.5476	1.20	1.75	



The grain size was maximum for Sensodyne, then biodentine and least in GC tooth moose.
On comparison using one-way Anova test, significant difference was seen among all three groups.
On pair wise comparison, significant difference was seen between group a and group b
group a and group c
group b and group c
Graph 1: Comparative Evaluation of Efficacy of Milk Proteins, Biodentine, Fluoride Containing Toothpaste

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SENSODYNE	BIODENTINE	1.12900*	.08084	.000	.9345	1.3235
	GC TOOTH MOUSSE	1.56250*	.08084	.000	1.3680	1.7570
BIODENTINE	GC TOOTH MOUSSE	.43350*	.08084	.000	.2390	.6280
*. The mean difference is significant at the 0.05 level.						

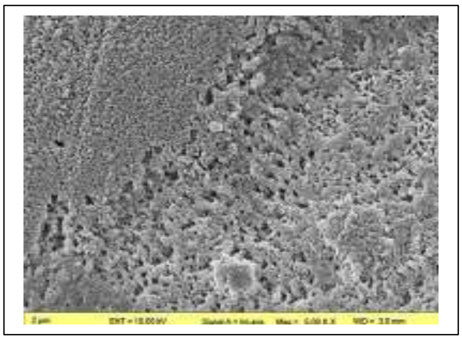


Figure 1.

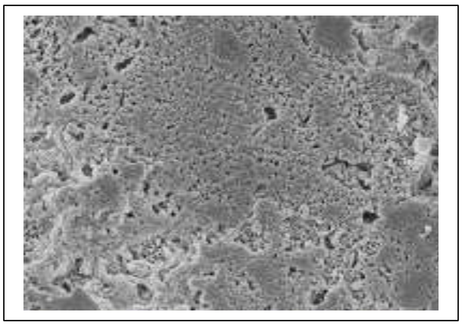


Figure 2.

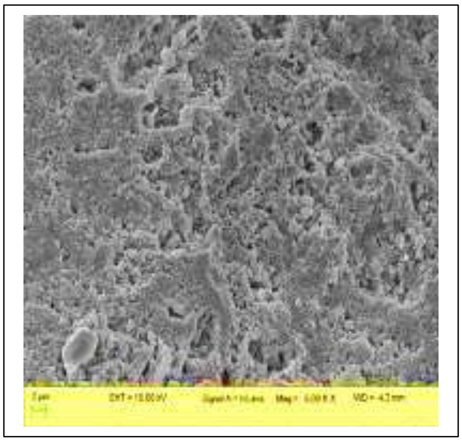


Figure 3.

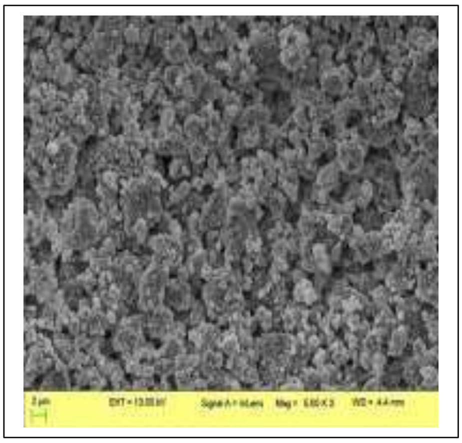


Figure 4.

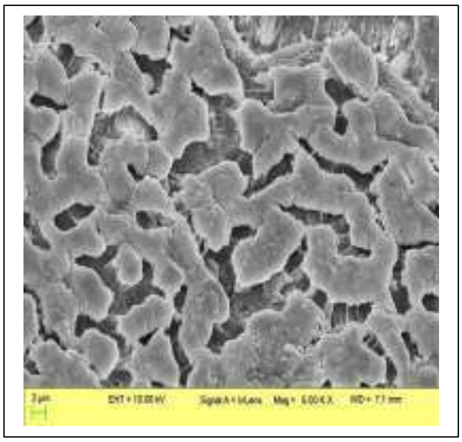


Figure 5.

DISCUSSION

Dentinal hypersensitivity, characterized by acute, transient pain originating from exposed dentin in response to various stimuli is often misdiagnosed. This discomfort can substantially affect a patient's quality of life, causing significant distress.(15) The pathophysiology of dentinal hypersensitivity is intricately linked to the exposure of dentinal tubules, which often results from mechanical wear, dietary habits, or gingival recession from periodontal disease. The hydrodynamic theory says that external stimuli cause a rapid movement of fluid within the dentinal tubules. This fluid movement creates pressure changes that stimulate the mechanoreceptors within the dental pulp, leading to the perception of pain.(16) In clinical practice, addressing dentinal hypersensitivity involves a comprehensive approach that includes identifying and mitigating the underlying causes, such as reinforcing oral hygiene practices to prevent enamel erosion and managing periodontal health to prevent gingival recession.(10) Additionally, treatment strategies may involve the application of desensitizing agents that occlude the dentinal tubules to reduce fluid movement. A thorough understanding of both the etiology and the management of dentinal hypersensitivity is essential for effective patient care.(16)Therefore, this study was designed to examine the bioactive properties of potential desensitization agents to reduce dentin hypersensitivity. The literature regarding the effectiveness of GC Tooth Mousse^{R} isn't scarce and like the other researches done prior to this one, it has proven to be a good desensitizing agent in our research as well. When the grain size was studied in the scanning electron microscope, it was found to be comparatively the least among all study groups. The less the grain size, more is the occlusion of the dentinal tubules hence, more is the efficacy of the material used. According to a study done by P Ratnakar, Kasturi A Biradar, Veerendra Patil, Surabh G Rairam, Supriya Patil, Sangeeta Kulkarni on Influence of three different types of desensitizing agents on bond strength of etch-and-rinse and self-etch adhesive system on dentin: An in vitro study in 2023, also stated that the occlusion of dentinal tubules was more deeply rooted.(17) This might be as a result of the action of CPP-ACP, which releases $Ca^{2+}$and $PO_4^{3-}$to maintain a supersaturated environment and obturate dentinal tubules with remineralized dentin.The GC Tooth Mousse has Casein phosphopeptide–amorphous calcium phosphate complexes (CPP–ACP), a milk product which helps in remineralization and prevents dental caries. Casein phosphopeptide can deliver amorphous calcium phosphate and can also help the ACP to bind with the dental enamel. It works by forming mineral precipitates containing fluorapatite by infusing calcium and phosphate ions in the tooth surfaces with pellicle and plaque.(1) Hence, GC Tooth Mousse is indeed a potential desensitization agent and can reduce dentin permeability. Biodentine[R] is a calcium-based silicate cement that studies suggest may occlude dentinal tubules with stable, acid-resistant calcium phosphate deposits.(In our research, the images from the SEM analysis have shown partial occlusion of dentinal tubules. The grain size seen in the images from SEM analysis is relatively larger than those seen in the cases of GC Tooth Mousse but smaller than the ones seen in the cases of fluoride containing toothpaste. The tricalcium silicate and calcium carbonate present in the biodentine possess desensitizing properties. The hydration process of calcium silicate based cement leads to the release of calcium hydroxide and consequently, the formation of biological appetite in the presence of phosphate containing fluids. The remineralising properties of biodentine have shown to considerably reduce the dentin permeability. According to a study by Melina Brizuela; Joseph O. Daley on Dental Materials: Biodentine, a Calcium Silicate Bioactive

In 2024, the research also indicated that Biodentine adapts well to dentine due to micromechanical adhesion.(18)The fluoride containing toothpaste i.e., Sensodyne[R] also has desensitizing properties. According to a study by Meng Yang, Hong Lin, Ruodan Jiang, Gang Zheng on Effects of desensitizing toothpastes on the permeability of dentin after different brushing times: An in vitro study in 2016, Sensodyne Repair and Protect (calcium sodium phosphosilicate) reduced dentin permeability significantly compared with continuous brushing.(19) The fluoride ion binds with the appetite crystals to form fluorapatite which in turn is more resistant to sensitivity than the naturally occurring hydroxyapatite crystals. The images obtained from SEM for this study group showed the largest grain size of all three study groups i.e., it was the least effective desensitizing agent of all.

CONCLUSION

According to the SEM/EDX analysis, all the materials used in the study were able to show potential desensitizing properties. Sendodyne being the least effective of all followed by biodentine in the increasing order of their efficacy as desensitizing agents. GC Tooth Mousse however, gave the best results of all.

REFERENCES

1.Barkatullah M, Farook MS, Mahmoud O. The Effectiveness of Remineralizing Agents on Dentinal Permeability. Biomed Res Int. 2018 Sep 12;2018:4072815. doi: 10.1155/2018/4072815. PMID: 30276206; PMCID: PMC6157146.

2.Pandey R., Koppolu P., Kalakonda B., et al. Treatment of dentinal hypersensitivity using low-level laser therapy and 5% potassium nitrate: A randomized, controlled, three arm parallel clinical study. International Journal of Applied and Basic Medical Research. 2017;7(1):p. 63. doi: 10.4103/2229-516X.198526. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

3.Gillam D. G., Mordan N. J., Newman H. N. The Dentin Disc surface: a plausible model for dentin physiology and dentin sensitivity evaluation. Advances in Dental Research. 1997;11(4):487–501. doi: 10.1177/08959374970110041701. [PubMed] [CrossRef] [Google Scholar]

4.Pashley D. H. How can sensitive dentine become hypersensitive and can it be reversed? Journal of Dentistry. 2013;41(4):S49–S55. doi: 10.1016/S0300-5712(13)70006-X. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

5.Ahmed T. R., Mordan N. J., Gilthorpe M. S., Gillam D. G. In vitro quantification of changes in human dentine tubule parameters using SEM and digital analysis. Journal of Oral Rehabilitation. 2005;32(8):589–597. doi: 10.1111/j.1365-2842.2005.01473.x. [PubMed] [CrossRef] [Google Scholar]

6.Brännström M. The hydrodynamic theory of dentinal pain: sensation in preparations, caries, and the dentinal crack syndrome. Journal of Endodontics. 1986;12(10):453–457. doi: 10.1016/s0099-2399(86)80198-4. [PubMed] [CrossRef] [Google Scholar]

7.Madhavan S., Habibullah M. A., B H., Varma L., Shetty R. Management strategies for dentinal hypersensitivity: a review. International Journal of Science and Research. 2018;6(11) [Google Scholar]

8.Zhong Y., Liu J., Li X., et al. Effect of a novel bioactive glass-ceramic on dentinal tubule occlusion: An in vitro study. Australian Dental Journal. 2015;60(1):96–103. doi: 10.1111/adj.12241. [PubMed] [CrossRef] [Google Scholar]

9.Anastasiou A. D., Strafford S., Posada-Estefan O., et al. β-pyrophosphate: A potential biomaterial for dental applications. Materials Science and Engineering C: Materials for Biological Applications. 2017;75:885–894. doi: 10.1016/j.msec.2017.02.116. [PubMed] [CrossRef] [Google Scholar]

10. Fernando D., Attik N., Pradelle-Plasse N., Jackson P., Grosgogeat B., Colon P. Bioactive glass for dentin remineralization: A systematic review. Materials Science and Engineering C: Materials for Biological Applications. 2017;76:1369–1377. doi: 10.1016/j.msec.2017.03.083. [PubMed] [CrossRef] [Google Scholar]
11. Reynolds E. C. Casein phosphopeptide-amorphous calcium phosphate: the scientific evidence. Advances in Dental Research. 2009;21(1):25–29. doi: 10.1177/0895937409335619. [PubMed] [CrossRef] [Google Scholar]
12. Azarpazhooh A., Limeback H. Clinical efficacy of casein derivatives a systematic review of the literature. The Journal of the American Dental Association. 2008;139(7):915–924. doi: 10.14219/jada.archive.2008.0278. [PubMed] [CrossRef] [Google Scholar] Camilleri J. Investigation of Biodentine as dentine replacement material. Journal of Dentistry. 2013;41(7):600–610. doi: 10.1016/j.jdent.2013.05.003. [PubMed] [CrossRef] [Google Scholar]
13. Mordan N. J., Barber P. M., Gillam D. G. The dentine disc. A review of its applicability as a model for the in vitro testing of dentine hypersensitivity. Journal of Oral Rehabilitation. 1997;24(2):148–156. doi: 10.1046/j.1365-2842.1997.d01-260.x. [PubMed] [CrossRef] [Google Scholar]
14. Elgalaid T. O., Creanor S. L., Creanor S., Hall A. F. The permeability of natural dentine caries before and after restoration: An in vitro study. Journal of Dentistry. 2007;35(8):656–663. doi: 10.1016/j.jdent.2007.05.004. [PubMed] [CrossRef] [Google Scholar]
15. Vongsavan N., Matthews R. W., Matthews B. The permeability of human dentin in vitro and in vivo. Archives of Oral Biolog. 2000;45(11):931–935. doi: 10.1016/S0003-9969(00)00079-0. [PubMed] [CrossRef] [Google Scholar]
16. Elgalaid T. O., Creanor S. L., Creanor S., Hall A. F. The repeatability of human dentine permeability measurement in vitro. Journal of Dentistry. 2008;36(1):42–48. doi: 10.1016/j.jdent.2007.10.005. [PubMed] [CrossRef] [Google Scholar]
17. Ratnakar P, Biradar KA, Patil V, Rairam SG, Patil S, Kulkarni S. Influence of three different types of desensitizing agents on bond strength of etch-and-rinse and self-etch adhesive system on dentin: An in vitro study. J Conserv Dent Endod. 2023 Sep-Oct;26(5):525-529. doi: 10.4103/JCDE.JCDE_36_23. Epub 2023 Sep 16. PMID: 38292373; PMCID: PMC10823955.
18. Malkondu Ö, Karapinar Kazandağ M, Kazazoğlu E. A review on biodentine, a contemporary dentine replacement and repair material. Biomed Res Int. 2014;2014:160951. doi: 10.1155/2014/160951. Epub 2014 Jun 16. PMID: 25025034; PMCID: PMC4082844.
19. Yang M, Lin H, Jiang R, Zheng G. Effects of desensitizing toothpastes on the permeability of dentin after different brushing times: An in vitro study. Am J Dent. 2016 Dec;29(6):345-351. PMID: 29178723.