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Original Research

Synergistic Effects Of Dentifrices And Diode Laser Therapy On Dentinal Tubule Occlusion

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ABSTRACT

Background: Dentinal hypersensitivity is a prevalent dental condition characterized by sharp pain in response to thermal, tactile, or chemical stimuli due to exposed dentinal tubules. Effective management aims to occlude these tubules to reduce sensitivity. Combining desensitizing dentifrices with diode laser therapy has emerged as a potential strategy to enhance tubule occlusion.

Methods: This in vitro study evaluated the synergistic effects of two dentifrices—Calcium Sodium Phosphosilicate (Novamin) and Fluoro Calcium Phospho Silicate (Biomin)—in combination with diode laser therapy on dentinal tubule occlusion. A total of 120 dentin specimens from extracted sound premolars were divided into six groups: Group 1 (Biomin), Group 2 (Novamin), Group 3 (Biomin + Diode Laser), Group 4 (Novamin + Diode Laser), Group 5 (Diode Laser alone), and Group 6 (Distilled Water Control). Treatments were applied using a battery-powered toothbrush, followed by laser irradiation where applicable. Scanning Electron Microscopy (SEM) was utilized to assess tubule occlusion, and data were analyzed using one-way ANOVA.

Results: Group 3 (Biomin + Diode Laser) exhibited the highest mean percentage of completely occluded tubules (79.27%), significantly outperforming other groups. Group 1 (Biomin alone) followed by Group 4 (Novamin + Diode Laser) also demonstrated substantial occlusion. The control group showed minimal occlusion (2.68%). Partial occlusion was highest in Group 5 (Diode Laser alone), while non-occluded tubules were significantly reduced in all experimental groups compared to control.

Conclusion: The combination of Fluoro Calcium Phospho Silicate (Biomin) with diode laser therapy significantly enhances dentinal tubule occlusion compared to individual treatments, suggesting a potential effective treatment modality for patients with dentinal hypersensitivity.

Keywords: Dentinal hypersensitivity, dentinal tubule occlusion, dentifrices, diode laser therapy, Fluoro Calcium Phospho Silicate, Calcium Sodium Phosphosilicate, in vitro study.

INTRODUCTION

Dentinal hypersensitivity is a widespread dental issue marked by transient, sharp pain emanating from exposed dentinal tubules in response to various stimuli such as thermal changes, tactile pressure, or chemical agents [1-8]. The hydrodynamic theory, introduced by Brännström, elucidates that fluid movement within these tubules triggers nerve responses, resulting in pain perception [1]. Effective management of dentinal hypersensitivity primarily focuses on strategies that either occlude the exposed tubules or desensitize the nerve responses to alleviate pain [2].

Traditional treatments encompass the use of desensitizing agents like potassium nitrate, stannous fluoride, and arginine-containing formulations, which function by blocking nerve transmission or precipitating within tubules to form a barrier [3-5]. Among these, bioactive glass formulations such as Calcium Sodium Phosphosilicate (Novamin) have garnered attention due to their ability to release calcium and phosphate ions, fostering the formation of hydroxycarbonate apatite, thereby effectively occluding dentinal tubules [6]. Similarly, Fluoro Calcium Phospho Silicate (Biomin) has emerged as a novel desensitizing agent, leveraging fluoride's remineralizing properties alongside phosphosilicate compounds to enhance tubule occlusion [7].

Concurrently, advancements in laser therapy have introduced adjunctive approaches to managing dentinal hypersensitivity. Diode lasers, characterized by specific wavelengths and photothermal properties, have been employed to induce structural changes in dentin, leading to tubule occlusion and reduced fluid flow [8,9]. The hypothesis that combining desensitizing agents with laser therapy may yield

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synergistic effects, thereby enhancing overall efficacy in dentinal tubule occlusion, has been posited [10].

Despite the documented individual successes of dentifrices and laser therapy, comprehensive studies exploring their combined effects systematically remain limited. This study aims to evaluate whether the combination of Calcium Sodium Phosphosilicate (Novamin) and Fluoro Calcium Phospho Silicate (Biomin) with diode laser therapy results in superior dentinal tubule occlusion compared to their standalone applications, potentially offering a more effective treatment modality for dentinal hypersensitivity.

MATERIALS AND METHODS

Study Design and Setting

This in vitro study was conducted at the Post Graduate Clinic of the Department of Periodontics and Orthodontics, Malabar Dental College and Research Centre. Scanning Electron Microscopy (SEM) analysis was performed at the Sophisticated Test and Instrumentation Centre, Cochin University of Science and Technology (CUSAT).

Study Population

A total of 120 dentin specimens were obtained from sound premolar teeth extracted for orthodontic purposes from patients aged 13 to 40 years. Extracted teeth were stored in 0.2% thymol solution at room temperature to maintain specimen integrity.

Materials

1. **Dentin Specimens:** 120 specimens from sound premolars.
2. **Dentifrices:**Biomin (Fluoro Calcium Phospho Silicate) and Novamin (Calcium Sodium Phosphosilicate) toothpastes (products of Group Pharma Company).
3. **Tools and Reagents:** Double-sided diamond disk, 18% EDTA, battery-powered toothbrush.
4. **Laser Equipment:** Diode laser (Epic 940 nm – Biolase Inc).
5. **SEM:** JEOL Model JSM-6390 LV for microstructural analysis.

Experimental Groups

- **Group 1:**Fluoro Calcium Phospho Silicate (Biomin)
- **Group 2:** Calcium Sodium Phosphosilicate (Novamin)
- **Group 3:**Biomin + Diode Laser
- **Group 4:**Novamin + Diode Laser
- **Group 5:** Diode Laser alone
- **Group 6:** Distilled Water (Control)

Inclusion and Exclusion Criteria

Included were extracted sound premolars without caries or fractures. Teeth with caries or fractures during extraction were excluded from the study.

Dentin Specimen Preparation

Teeth were externally cleaned using a scaler and then sectioned transversely using a carborundum disk to obtain coronal dentin discs approximately 2 mm thick. The exposed dentinal surfaces were polished with 600-grit carborundum paper and rinsed with distilled water. The smear layer was removed by applying 18% EDTA, followed by storage in 0.2% thymol solution.

Sampling Methods

Specimens were randomly assigned to six groups, with 20 samples per group as follows:

- **Group 1:**Biomin
- **Group 2:**Novamin
- **Group 3:**Biomin + Diode Laser
- **Group 4:**Novamin + Diode Laser
- **Group 5:** Diode Laser alone
- **Group 6:** Distilled Water (Control)

Treatment Procedure

Desensitizing dentifrice (Groups 1-4) was applied using a battery-powered toothbrush for 2 minutes, followed by a 2-minute rest. Groups 3 and 4, along with Group 5 (Laser alone), received diode laser irradiation at 940 nm, 2 W, for 60 seconds using a 400 µm optic fiber in a straight handpiece, held perpendicular to the dentinal surface at a 1 mm distance to prevent dentin contamination. All samples were rinsed with distilled water, air-dried in a desiccator, sputter-coated with gold, and examined under SEM.

SEM Analysis

Photomicrographs were captured at 3000X magnification to quantify total tubules, open tubules, completely occluded tubules, and partially occluded tubules. The percentage of occluded tubules was calculated by dividing the number of occluded tubules by the total number of tubules in each photomicrograph, multiplied by 100.

Statistical Analysis

Data were statistically analyzed using one-way Analysis of Variance (ANOVA) to compare the percentage of completely occluded, partially occluded, and non-occluded tubules across the six groups. A p-value of <0.05 was considered statistically significant.

RESULTS

The present study evaluated the effectiveness of two desensitizing dentifrices, Biomin and Novamin, in combination with diode laser therapy on dentinal tubule occlusion using 120 dentin specimens divided into six groups.

Complete Occlusion

Group 3 (Biomin + Diode Laser) exhibited the highest mean percentage of completely occluded tubules at 79.27%, followed by Group 1 (Biomin alone,

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69.41%), Group 4 (Novamin + Laser, 42.37%), Group 2 (Novamin alone, 30.29%), Group 5 (Laser alone, 8.77%), and the control Group 6 (Distilled Water, 2.68%) (Table 2, Graphs 1 & 2).

Partial Occlusion

Group 5 (Laser alone) demonstrated the highest mean percentage of partially occluded tubules (81.88%), followed by Group 2 (Novamin, 58.88%), Group 4 (Novamin + Laser, 56.12%), Group 6 (Control, 28.43%), Group 1 (Biomin, 23.84%), and Group 3 (Biomin + Laser, 17.98%) (Table 2, Graph 3).

Non-Occluded Tubules

Group 6 (Control) had the highest mean percentage of non-occluded tubules (68.89%), followed by Group 2 (Novamin, 10.83%), Group 5 (Laser alone, 9.36%), Group 1 (Biomin, 6.76%), Group 3 (Biomin + Laser, 2.24%), and Group 4 (Novamin + Laser, 1.5%) (Table 2, Graph 4).

Statistical Analysis

One-way ANOVA revealed statistically significant differences ($P<0.001$) among all groups for complete, partial, and non-occluded tubule percentages.

Intergroup Comparisons

- **Complete Occlusion:** Group 3 (79.27%) > Group 1 (69.41%) > Group 4 (42.37%) > Group 2 (30.29%) > Group 5 (8.77%) > Group 6 (2.68%) (Tables 3-7, Graphs 5-19).
- **Partial Occlusion:** Group 5 (81.88%) > Group 2 (58.88%) ≈ Group 4 (56.12%) > Group 6 (28.43%) > Group 1 (23.84%) > Group 3 (17.98%) (Tables 3-7, Graphs 6-18).
- **Non-Occluded Tubules:** Group 6 (68.89%) > Group 2 (10.83%) > Group 5 (9.36%) > Group 1 (6.76%) > Group 3 (2.24%) > Group 4 (1.5%) (Tables 3-7, Graphs 7-19).

The combination treatments (Groups 3 and 4) showed superior complete occlusion compared to their respective individual treatments (Groups 1 and 2). Additionally, diode laser alone (Group 5) resulted in high partial occlusion but minimal complete occlusion, indicating the necessity of combining laser therapy with desensitizing agents for optimal results.

Table: 1. Mean And Standard Deviation Of Completely Occluded, Partially Occluded, And Not Occluded Tubule Percentages In Six Groups

Tubule Response	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Completely Occluded	120	0.00	95.83	38.80	29.25
Partially Occluded	120	4.17	89.47	44.52	23.72
Not Occluded	120	0.00	78.26	16.60	24.43

Table: 2. Distribution Of Mean And Standard Deviation And Anova For Different Types Of Tubular Responses

Tubular Response	Group	N	Mean (%)	Std. Deviation	Std. Error Mean	95% Confidence Interval for Mean	Minimum (%)	Maximum (%)	F Value	P Value
Completely Occluded	1	20	69.41	9.96	2.23	64.74 - 74.07	54.55	95.83	494.6	<0.001
	2	20	30.29	7.23	1.62	26.91 - 33.68	20.83	44.44		
	3	20	79.27	6.70	1.50	76.13 - 82.40	65.52	90.91		
	4	20	42.37	4.86	1.09	40.09 - 44.64	27.27	46.43		
	5	20	8.77	3.70	0.83	7.03 - 10.50	0.83	10.50		
	6	20	2.68	1.53	0.34	1.97 - 3.40	0.00	5.26		
Partially Occluded	1	20	23.84	7.95	1.78	20.12 - 27.56	4.17	40.00	324.0	<0.001
	2	20	58.88	6.82	1.53	55.69 - 62.07	43.75	69.57		
	3	20	17.98	5.80	1.30	15.26 - 20.69	9.09	31.25		
	4	2	56.12	3.13	0.70	54.66 -	50.00	63.64		

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		0				57.59				
	5	20	81.88	6.03	1.35	79.06 - 84.70	69.23	89.47		
	6	20	28.43	6.49	1.45	25.40 - 31.47	20.29	40.00		
Not Occluded	1	20	6.76	5.91	1.32	3.99 - 9.52	0.00	21.21	381.0	<0.001
	2	20	10.83	6.17	1.38	7.94 - 13.72	0.00	22.73		
	3	20	2.24	3.18	0.71	0.75 - 3.73	0.00	10.71		
	4	20	1.51	3.70	0.83	-0.22 - 3.24	0.00	11.11		
	5	20	9.36	7.95	1.78	5.64 - 13.07	5.64	13.07		
	6	20	68.89	7.15	1.60	65.54 - 72.24	57.50	78.26		

Table: 3. Intergroup Comparison Of Group 1 And Group 3: Mean And Standard Deviation Of Different Tubular Responses

Tubular Response	Group	N	Mean (%)	Std. Deviation	Std. Error Mean	t Value	P Value
Completely Occluded	1	20	69.41	9.96	2.23	3.673	0.001
	3	20	79.27	6.70	1.50		
Partially Occluded	1	20	23.84	7.95	1.78	2.662	0.011
	3	20	17.98	5.80	1.30		
Not Occluded	1	20	6.76	5.91	1.32	3.014	0.005
	3	20	2.24	3.18	0.71		

Table: 4. Intergroup Comparison Of Group 2 And Group 4: Mean And Standard Deviation Of Different Tubular Responses

Tubular Response	Group	N	Mean (%)	Std. Deviation	Std. Error Mean	t Value	P Value
Completely Occluded	2	20	30.29	7.23	1.62	6.199	<0.001
	4	20	42.37	4.86	1.09		
Partially Occluded	2	20	58.88	6.82	1.53	1.642	0.109
	4	20	56.12	3.13	0.70		
Not Occluded	2	20	10.83	6.17	1.38	5.795	<0.001
	4	20	1.51	3.70	0.83		

Table: 5. Intergroup Comparison Of Group 2 And Group 5: Mean And Standard Deviation Of Different Tubular Responses

Tubular Response	Group	N	Mean (%)	Std. Deviation	Std. Error Mean	t Value	P Value
Completely Occluded	2	20	30.29	7.23	1.62	11.846	<0.001
	5	20	8.77	3.70	0.83		
Partially Occluded	2	20	58.88	6.82	1.53	11.299	<0.001
	5	20	81.88	6.03	1.35		
Not Occluded	2	20	10.83	6.17	1.38	0.656	0.516
	5	20	9.36	7.95	1.78		

Table: 6. Intergroup Comparison Of Group 1 And Group 5: Mean And Standard Deviation Of Different Tubular Responses

Tubular Response	Group	N	Mean (%)	Std. Deviation	Std. Error Mean	t Value	P Value
Completely Occluded	1	20	69.41	9.96	2.23	25.517	<0.001
	5	20	8.77	3.70	0.83		
Partially Occluded	1	20	23.84	7.95	1.78	26.021	<0.001
	5	20	81.88	6.03	1.35		
Not Occluded	1	20	6.76	5.91	1.32	1.173	0.248
	5	20	9.36	7.95	1.78		

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Table: 7. Intergroup Comparison Of Group 3 And Group 4: Mean And Standard Deviation Of Different Tubular Responses

Tubular Response	Group	N	Mean (%)	Std. Deviation	Std. Error Mean	t Value	P Value
Completely Occluded	3	20	79.27	6.70	1.50	19.94	<0.001
	4	20	42.37	4.86	1.09		
Partially Occluded	3	20	17.98	5.80	1.30	25.873	<0.001
	4	20	56.12	3.13	0.70		
Not Occluded	3	20	2.24	3.18	0.71	0.667	0.509
	4	20	1.51	3.70	0.83		

DISCUSSION

The management of dentinal hypersensitivity is crucial for improving patient comfort and quality of life. This study aimed to evaluate the synergistic effects of two desensitizing agents, Biomin and Novamin, in combination with diode laser therapy on dentinal tubule occlusion.

Efficacy of Desensitizing Agents

Biomin, containing Fluoro Calcium Phospho Silicate, demonstrated significant efficacy in occluding dentinal tubules, with Group 1 achieving 69.41% complete occlusion. This aligns with previous research indicating that fluoride-containing compounds enhance remineralization and tubule occlusion through the formation of hydroxyapatite [11]. Novamin, or Calcium Sodium Phosphosilicate, showed moderate efficacy (30.29% complete occlusion) when used alone, consistent with its mechanism of releasing calcium and phosphate ions to form a protective layer [12].

Synergistic Effects with Diode Laser

The combination of Biomin with diode laser therapy (Group 3) yielded the highest complete occlusion (79.27%), suggesting a synergistic effect. Diode lasers may enhance the penetration and binding of desensitizing agents into dentinal tubules by inducing thermal and photochemical changes in the dentin structure [8,10]. Similarly, the combination of Novamin with laser therapy (Group 4) resulted in improved occlusion (42.37%) compared to Novamin alone, although less effective than the Biomin combination.

Laser Therapy Alone

Diode laser therapy alone (Group 5) resulted in high partial occlusion (81.88%) but low complete occlusion (8.77%), indicating that while lasers can alter dentin structure and reduce tubule patency, they may not fully occlude tubules without the aid of desensitizing agents. This underscores the importance of combining laser therapy with appropriate desensitizing agents for optimal treatment outcomes.[13]

Control Group

The control group (Group 6) exhibited minimal occlusion (2.68%), reaffirming that without intervention, dentinal tubules remain largely open, maintaining the potential for hypersensitivity. This serves as a baseline demonstrating the effectiveness of the experimental treatments.[14]

Clinical Implications

The findings suggest that combining Fluoro Calcium Phospho Silicate (Biomin) with diode laser therapy could offer a more effective treatment modality for dentinal hypersensitivity than using either treatment alone. This combination could provide enhanced patient relief by achieving higher rates of tubule occlusion, thereby reducing sensitivity more effectively.

Limitations and Future Research

While the in vitro nature of this study provides controlled insights into the mechanisms of tubule occlusion, it may not fully replicate the complexities of the in vivo oral environment, such as the presence of saliva, biofilm, and mechanical stresses from mastication. Future studies should include clinical trials to validate these findings and assess the longevity and durability of tubule occlusion achieved through combined treatments. Additionally, exploring different laser parameters and desensitizing agent concentrations could optimize treatment protocols for maximum efficacy.

This study demonstrates that the combination of Fluoro Calcium Phospho Silicate (Biomin) with diode laser therapy significantly enhances dentinal tubule occlusion compared to individual treatments. These results advocate for the potential adoption of this synergistic approach in clinical settings to effectively manage dentinal hypersensitivity.

CONCLUSION

The combination of Fluoro Calcium Phospho Silicate (Biomin) with diode laser therapy significantly enhances dentinal tubule occlusion compared to individual treatments. This synergistic approach holds promise as an effective treatment modality for patients suffering from dentinal hypersensitivity, warranting further clinical investigation.

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