RESEARCH PAPER

Comparative Clinical Evaluation Of Glass Ionomer, Fluoride Releasing And Nano Silver Reinforced Pit And Fissure Sealants.

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Abstract

Background: Newly erupted permanent molars are highly prone to dental caries due to deep pits and fissures that promote plaque retention. Pit and fissure sealants serve as an effective preventive modality in Pediatric dentistry. Recent developments, including fluoride-releasing and nano-silver incorporated sealants, aim to enhance antibacterial properties and improve long-term clinical performance.

Aim: To evaluate and compare the retention, marginal integrity and caries-preventive efficacy of three different pit and fissure sealant materials over a period of 12 months.

Materials and Methods: A randomized clinical trial was conducted on 105 permanent mandibular first molars using split mouth design in children aged 6–9 years. The teeth were randomly allocated into three groups (n = 35 in each): Group I—glass ionomer-based sealant; Group II—fluoride-releasing resin-based sealant; Group III—nano-silver incorporated sealant. Clinical assessment was performed at baseline, 6 months,9th months and 12 months using standardized criteria to evaluate retention, marginal adaptation, surface characteristics, and caries occurrence. Statistical analysis was performed with the level of significance set at $p < 0.05$.

Results: At the end of 12 months, all three sealant materials demonstrated satisfactory clinical performance. The resin-based sealant showed slightly higher retention compared to the glass ionomer sealant, although the difference was not statistically significant ($p > 0.05$). The nano-silver sealant exhibited performance comparable to the resin-based sealant. No significant differences were observed among the groups in terms of secondary caries occurrence.

Conclusion: All three sealant materials were effective in preventing occlusal caries over the 12-month study period. The incorporation of nano-silver did not negatively affect the clinical performance of the sealant.

Keywords: Pit and fissure sealants; Glass ionomer cement; Resin-based sealant; Nano-silver; Dental caries; Preventive dentistry

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INTRODUCTION

Dental caries is a multifactorial infectious disease resulting from the interaction of host, microorganisms, diet, and environmental factors, and it can affect any tooth in the oral cavity.[1] The occlusal surfaces of teeth, characterized by pits and fissures, are highly susceptible to caries due to their complex morphology. These deep and narrow grooves favor the accumulation of food debris and microorganisms and are difficult to clean effectively with routine oral hygiene practices.

The narrow configuration of fissures also limits the natural cleansing action of saliva, which plays an essential role in buffering acids and supplying minerals for enamel remineralization. Similarly, fluoride penetration into these areas is often restricted, reducing its protective effect. Surface tension further inhibits the entry of saliva and fluoride into deep fissures, increasing their vulnerability to caries compared to smooth surfaces.[2] Based on their morphology, pits and fissures are classified as "V," "U," "I," and "K" types. "V" and "U" types are self-cleansable and suitable for non-invasive sealing, whereas "I" and "K" types are non-self-cleansable and may require invasive techniques.[2]

Pit and fissure sealants are an effective preventive measure that act by sealing these vulnerable areas, thereby preventing plaque accumulation and bacterial colonization. They create a smooth surface that facilitates easier cleaning and significantly reduce the risk of occlusal caries in both primary and permanent teeth.[3,4] Glass ionomer cement (GIC) sealants are advantageous due to their hydrophilic nature and fluoride-releasing ability, allowing them to perform well

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in moist conditions and promote remineralization. Although they have lower retention compared to resin-based sealants, they remain effective in caries prevention.[5]

Resin-based sealants, particularly fluoride-releasing types such as Helioseal-F, provide strong mechanical retention along with cariostatic benefits. Advances in material science have led to improved formulations like Helioseal F Plus, which offers better flow properties and reduced polymerization time.[6]

Recent developments in nanotechnology have introduced silver nanoparticles (AgNPs) as promising agents in caries prevention. AgNPs exhibit broad-spectrum antibacterial activity by disrupting bacterial cell membranes, inhibiting enzyme activity, and interfering with DNA replication and protein synthesis, ultimately leading to cell death.[7,8] These properties have led to their incorporation into dental materials, including pit and fissure sealants, to enhance antimicrobial efficacy.

Although in vitro studies have demonstrated favorable properties such as good shear bond strength for nanosilver-incorporated sealants, clinical evidence comparing their performance with conventional sealants remains limited.[8] Therefore, the present study aims to comparatively evaluate glass ionomer–based,Floride releasing resin-based, and nanosilver-reinforced pit and fissure sealants based on retention, marginal integrity, and caries prevention.

MATERIALS AND METHODS

A randomized, triple-blind in vivo clinical trial (blinding participants, evaluators, and statisticians) using a split-mouth design was conducted on children aged 6–9 years old in permanent mandibular first molars at the Department of Pedodontics and Preventive Dentistry, Sri Siddhartha Dental College, Tumkur. Ethical approval was obtained from the Sri Siddhartha Dental College and Hospital Institutional Ethical Committee (SSDCH-IEC No: SSDCH-IEC/2024/34).

- **Inclusion Criteria**:

1.Bilaterally erupted permanent mandibular first molars exhibiting deep pits and fissures.
2.Boys and girls between the ages of 6 and 9 years.
3.dft score of 1,2 or 3
4.Children exhibiting satisfactory cooperative behavior, indicated by frankl score of 3or 4.
5.Children who demonstrated good oral hygiene, defined by an OHI-S score of less than 3 were included.
4.Children exhibiting bruxism, malocclusion, or hypersensitivity to dental materials or resins.

Exclusion Criteria:

1.Patient with rampant caries
2.Patient undergoing orthodontic treatment
3.Presence of any dental anomalies
4.Medically compromised individuals or those with physical or mental disabilities.
5.Patients who are severely uncooperative.
6.Wide self -cleansing pit and fissures.

METHODOLOGY

A total of 105 permanent mandibular first molars that satisfied the predefined inclusion criteria were were recruited for the study. **The samples were stratified into three** groups of equal size through computer-generated randomization using an online randomization program (Random.org) to ensure unbiased distribution.

- **Group A:** Glass ionomer–based pit and fissure sealant (Fuji IX)
- **Group B:** Fluoride-releasing pit and fissure sealant (Helioseal-F Plus)
- **Group C:** Nanosilver-incorporated pit and fissure sealant (e-pit and fissure sealant)

The treatment protocol was implemented by a single operator using full isolation techniques.

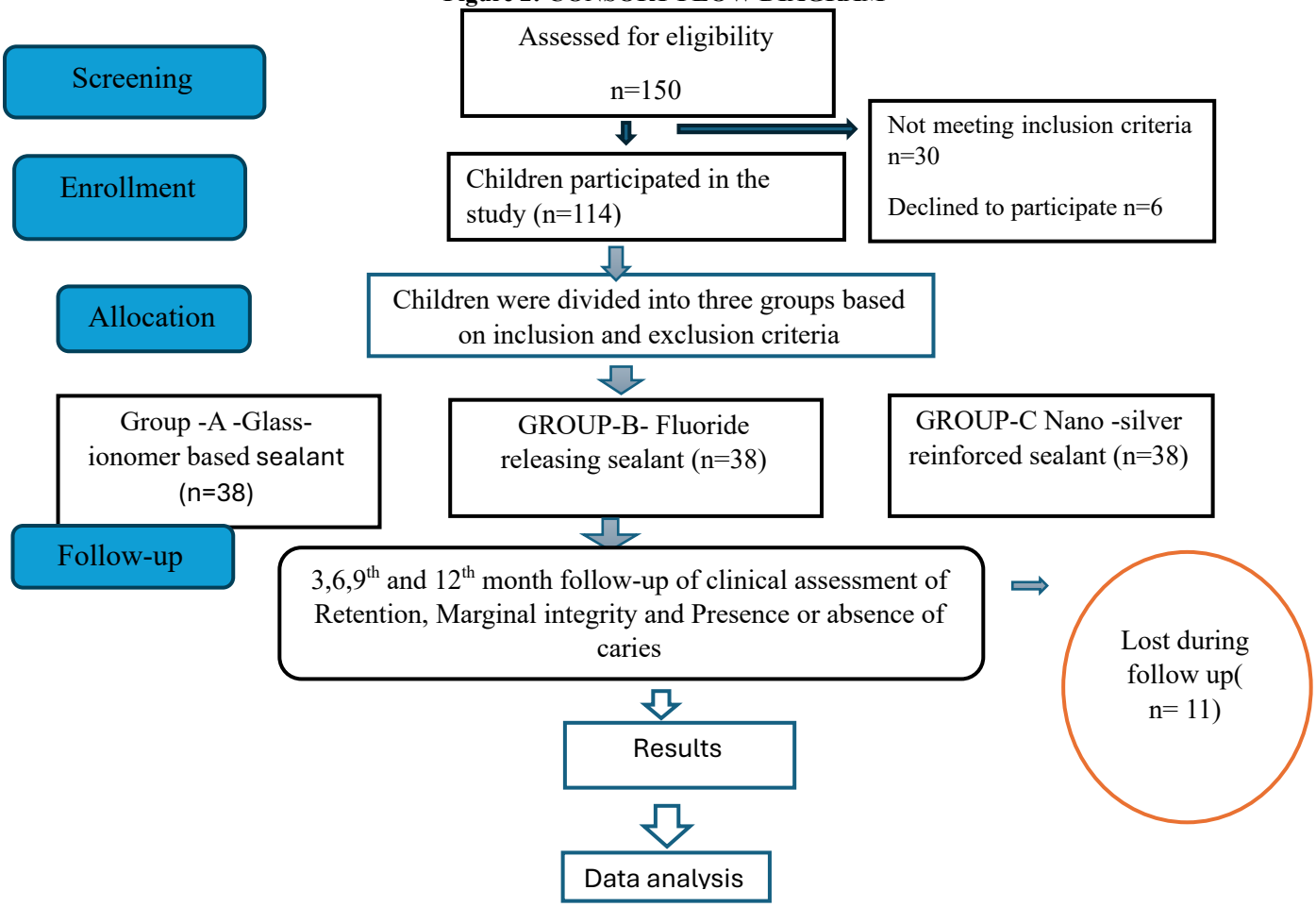
a)Glass-ionomer based sealant

b)Fluoride releasing pit and fissure sealant

c)Nano silver reinforced pit and fissure sealant

- **FIGURE 1: a)** Glass ionomer–based pit and fissure sealant (Fuji IX),b) Fluoride-releasing pit and fissure sealant (Helioseal-F Plus) c) Nanosilver-reinforced pit and fissure sealant (e-pit and fissure sealant)

Figure 2: CONSORT FLOW DIAGRAM



PROCEDURE FOR PIT AND FISSURE SEALANT APPLICATION

Group A: Glass Ionomer Sealant (Fuji IX)

The occlusal surfaces were conditioned with GC Dentine Conditioner for 20 seconds, rinsed, and gently air-dried. Fuji IX was mixed as per manufacturer's instructions and applied to the pits and fissures. A layer of varnish was placed to protect against moisture, and the material was allowed to set for 4 minutes. Rubber dam isolation was maintained, and occlusion was checked and adjusted using articulating paper.[1,2]

Group B: Fluoride-Releasing Sealant (Helioseal F Plus)

After rubber dam isolation, the enamel was etched with 37% phosphoric acid for 20 seconds, rinsed, and air-dried until a chalky white appearance was achieved. The sealant was applied carefully without air bubbles and light-cured for 30 seconds. Occlusion was evaluated and adjusted as necessary.[2]

Group C: Nano-Silver Reinforced Sealant

The enamel was etched with 37% phosphoric acid for 20 seconds, rinsed, and air-dried. The nano-silver sealant was applied ensuring proper penetration and absence of voids, followed by light curing for 40 seconds. Rubber dam isolation was maintained, and occlusion was checked and adjusted.[7]

CLINICAL EVALUATION CRITERIA:

A comprehensive clinical examination was conducted by a single trained and calibrated evaluator who is blinded pertaining to the group and material allocation.

- **CARIES EVALUATION:**

Caries status was determined using visual and tactile inspection using an explorer, by Modified Simonsen's criteria. The first follow-up occurred at three months, with additional evaluations at six, nine, and twelve months. Intraoral camera images of all permanent mandibular first molars were taken, and evaluations were made in line with the USPHS criteria.[9]

- **MARGINAL INTEGRITY EVALUATION:**

Follow-up assessments of the sealants' marginal integrity were carried out at 3, 6, 9, and 12 months post-treatment using an intraoral camera and a dental explorer, following the USPHS evaluation criteria.[9]

- **RETENTION EVALUATION:**

Retention of the sealants was assessed by comparing baseline and follow-up images, with scoring conducted according to the USPHS criteria [9]and the Modified Simonsen's criteria.[1]

Table 1: Criteria Sealant position: USPHS criteria.[9]

Retention	Alpha: present Bravo: partially present Charlie: Lost
Marginal integrity	Alpha: Excellent margin with no evidence of crevice Bravo: An acceptable margin with small crevice detected Charlie: An unacceptable margin with large crevice detected
Caries	Alpha: Absent Bravo: Present

- MODIFIED SIMONSEN`S CRITERIA FOR SEALANT RETENTION[10]:

Sealant retention was examined clinically using a dental mirror and probe, in line with the modified Simonsen's evaluation criteria.[10]

Table 2:MODIFIED SIMENSON`S EVALUATION CRITERIA

Score 0	No loss of sealant and no evidence of caries
Score 1	Partial loss and no evidence of caries
Score 2	Partial loss of sealant and evidence of caries
Score 3	Complete loss of sealant and non evidence of caries
Score 4	Complete loss of sealant and evidence of caries

STATISTICAL ANALYSIS

Data was analyzed using the statistical package **SPSS 26.0** (SPSS Inc., Chicago, IL) and level of significance was set at **P<0.05**. **Descriptive statistics** was performed to assess the mean and standard deviation of the respective groups. **Pearson Chi square test** was used for comparison of categories.

RESULTS

A randomized clinical trial was conducted among 6–9-year-old children in permanent mandibular first molars at the Department of Pediatric and Preventive Dentistry to assess and compared the Clinical success of which includes Glass ionomer pit and fissure sealant (Fuji IX),Fluoride releasing pit and fissure sealant (Helioseal-F plus), Nano silver reinforced (e- pit and fissure) sealant with respect to retention, marginal integrity and presence of caries.

The mean age of participants in Group A was 7.42 ± 0.95 years, while Groups B and C had mean ages of 7.49 ± 1.12 years and 7.49 ± 1.07 years, respectively. The age range in all groups was 6–9 years. Among 114 participants, 36.8% were female and 63.2% were male. Each group included 38 participants. The sex distribution was comparable across Group A, Group B, and Group C, with no statistically significant difference.

Table 3- Comparison of 'USPHS criteria- Retention'

			GROUPS			Total	X^2 Value	P Value (Between group)
			GROUP A	GROUP B	GROUP C			
After	A	Count	38	38	38	114		
		%	100.0%	100.0%	100.0%	100.0%		
3 months	A	Count	37	36	36	109	0.41	0.81
		%	97.4%	94.7%	94.7%	95.6%		
	No follow up	Count	1	2	2	5		
		%	2.6%	5.3%	5.3%	4.4%		
	A	Count	37	36	36	109		

6 months		%	97.4%	94.7%	94.7%	95.6%	0.41	0.81
	No follow up	Count	1	2	2	5		
		%	2.6%	5.3%	5.3%	4.4%		
9 months	A	Count	27	30	29	86	1.89	0.93
		%	71.1%	78.9%	76.3%	75.4%		
	B	Count	5	5	5	15		
		%	13.2%	13.2%	13.2%	13.2%		
	C	Count	1	0	1	2		
		%	2.6%	0.0%	2.6%	1.8%		
	No follow up	Count	5	3	3	11		
		%	13.2%	7.9%	7.9%	9.6%		
12 months	A	Count	25	30	26	81	3.56	0.76
		%	65.8%	78.9%	68.4%	71.1%		
	B	Count	4	1	3	8		
		%	10.5%	2.6%	7.9%	7.0%		
	C	Count	4	4	6	14		
		%	10.5%	10.5%	15.8%	12.3%		
	No follow up	Count	5	3	3	11		
		%	13.2%	7.9%	7.9%	9.6%		
Chi Square test			56.23	48.76	44.67			
P Value (Within group)			0.0001*	0.0001*	0.0001*			

All sealants were rated Alpha (100%) at baseline. At 3 and 6 months, high retention was observed (GROUP A: 97.4%; GROUP B and C: 94.7%) with no significant intergroup differences ($p > 0.05$).At 9 and 12 months, Alpha scores decreased with a corresponding increase in Bravo and Charlie scores; however, intergroup differences remained statistically non-significant ($p > 0.05$).Intragroup comparison showed a statistically significant decline in retention over time in all groups ($p < 0.0001$) as showed in Table 3.

Table 4- Comparison of 'USPHS -Marginal Integrity'

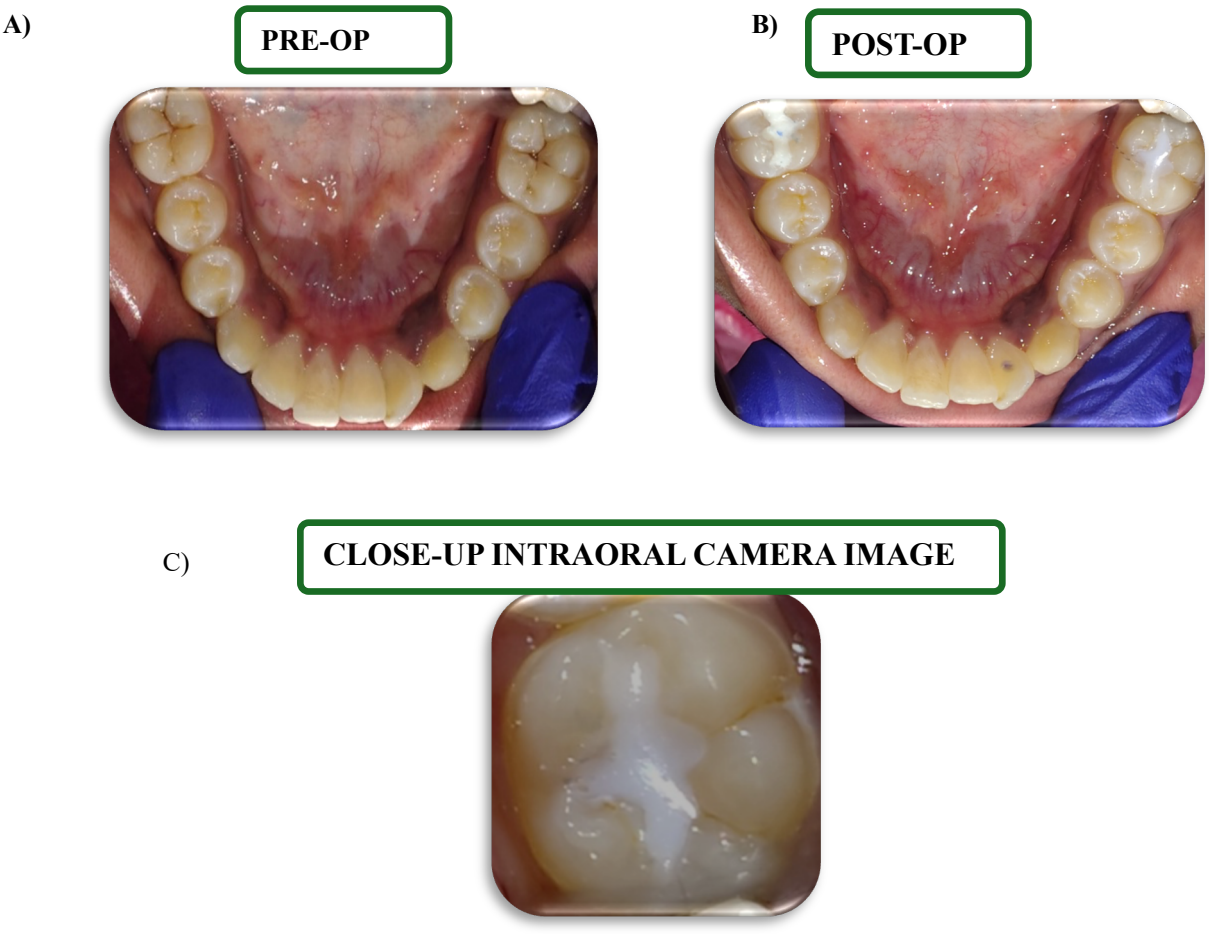
			GROUPS			Total	X^2 Value	P Value (Between group)
			GROUP A	GROUP B	GROUP C			
After	A	Count	38	38	38	114	-	-
		%	100.0%	100.0%	100.0%	100.0%		
3 months	A	Count	37	36	36	109	0.41	0.81
		%	97.4%	94.7%	94.7%	95.6%		
	No follow up	Count	1	2	2	5		
		%	2.6%	5.3%	5.3%	4.4%		
6 months	A	Count	37	36	36	109	0.41	0.81
		%	97.4%	94.7%	94.7%	95.6%		
	No follow up	Count	1	2	2	5		
		%	2.6%	5.3%	5.3%	4.4%		
9 months	A	Count	27	30	29	86	1.89	0.93
		%	71.1%	78.9%	76.3%	75.4%		
	B	Count	5	5	5	15		
		%	13.2%	13.2%	13.2%	13.2%		
	C	Count	1	0	1	2		
		%	2.6%	0.0%	2.6%	1.8%		
	No follow up	Count	5	3	3	11		
		%	13.2%	7.9%	7.9%	9.6%		
12 months	A	Count	25	30	26	81	3.56	0.74
		%	65.8%	78.9%	68.4%	71.1%		
	B	Count	4	1	3	8		
		%	10.5%	2.6%	7.9%	7.0%		
	C	Count	4	4	6	14		
		%	10.5%	10.5%	15.8%	12.3%		
	No follow up	Count	5	3	3	11		

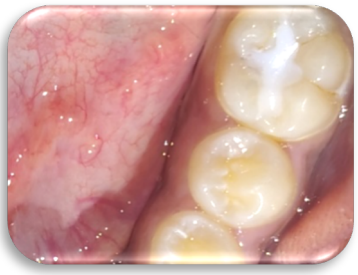
		%	13.2%	7.9%	7.9%	9.6%		
Chi Square test			66.76	57.65	55.57			
P Value (Within group)			0.0001*	0.0001*	0.0001*			

All sealants were rated Alpha (100%) at baseline. At 3 and 6 months, high marginal integrity was maintained (GROUP A: 97.4%; GROUP B and C: 94.7%) with no significant intergroup differences ($p > 0.05$).

At 9 and 12 months, Alpha scores decreased with an increase in Bravo and Charlie scores; however, intergroup differences remained statistically non-significant ($p > 0.05$).Intragroup comparison showed a statistically significant decline in marginal integrity over time in all groups ($p < 0.0001$) as showed in Table 4.

FIGURE 3:GROUP A SEALANT GROUP A)PRE-OP B)POST-OP C) CLOSE-UP INTRAORAL CAMERA IMAGE D)3RD MONTH E) 6TH FOLLOW -UP F)9TH MONTH FOLLOW-UP G)12TH MONTH FOLLOW-UP





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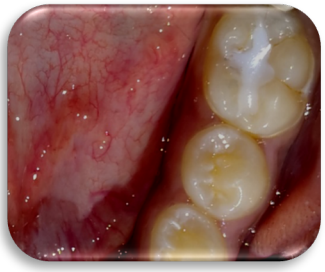
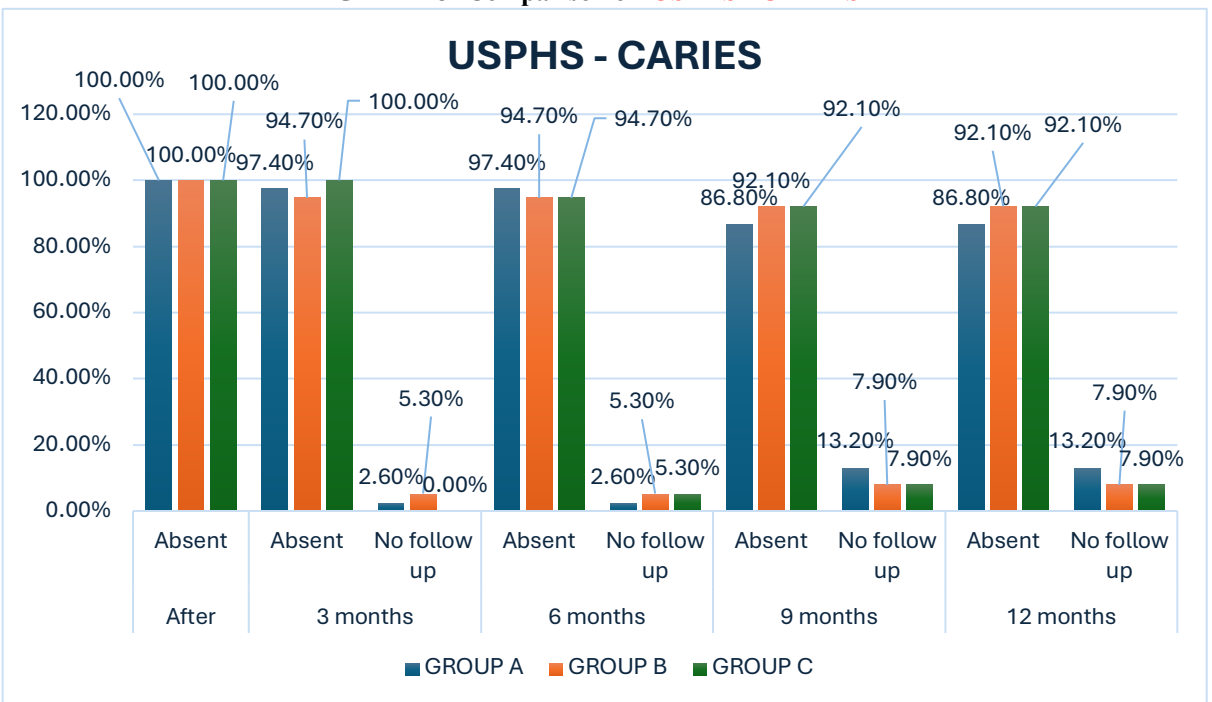


F) 9th month

12th month

GRAPH 3- Comparison of 'USPHS - CARIES'



Between-group comparison of USPHS caries scores demonstrated no statistically significant difference among Group A, Group B, and Group C at any of the evaluated follow-up intervals ($p > 0.05$). At baseline, all restorations across the three groups were caries-free, indicating complete uniformity at the start of the study.

At 3,6,9 and 12th month follow-up the proportion of caries-free restorations remained high.As there was no caries was detected in any of the participants examined during follow-up.As there was lost follow-up in all the groups as shown in GRAPH 3.The difference is seen which is statistically no difference

FIGURE 4: GROUP-B SEALANT GROUPA)PRE-OPB)POST-OPC)CLOSE-UP INTRAORAL CAMERA IMAGE D)3RD MONTH FOLLOW-UP E)6TH MONTH FOLLOW-UP F)9TH MONTH FOLLOW-UP G)12TH MONTH FOLLOW-UP

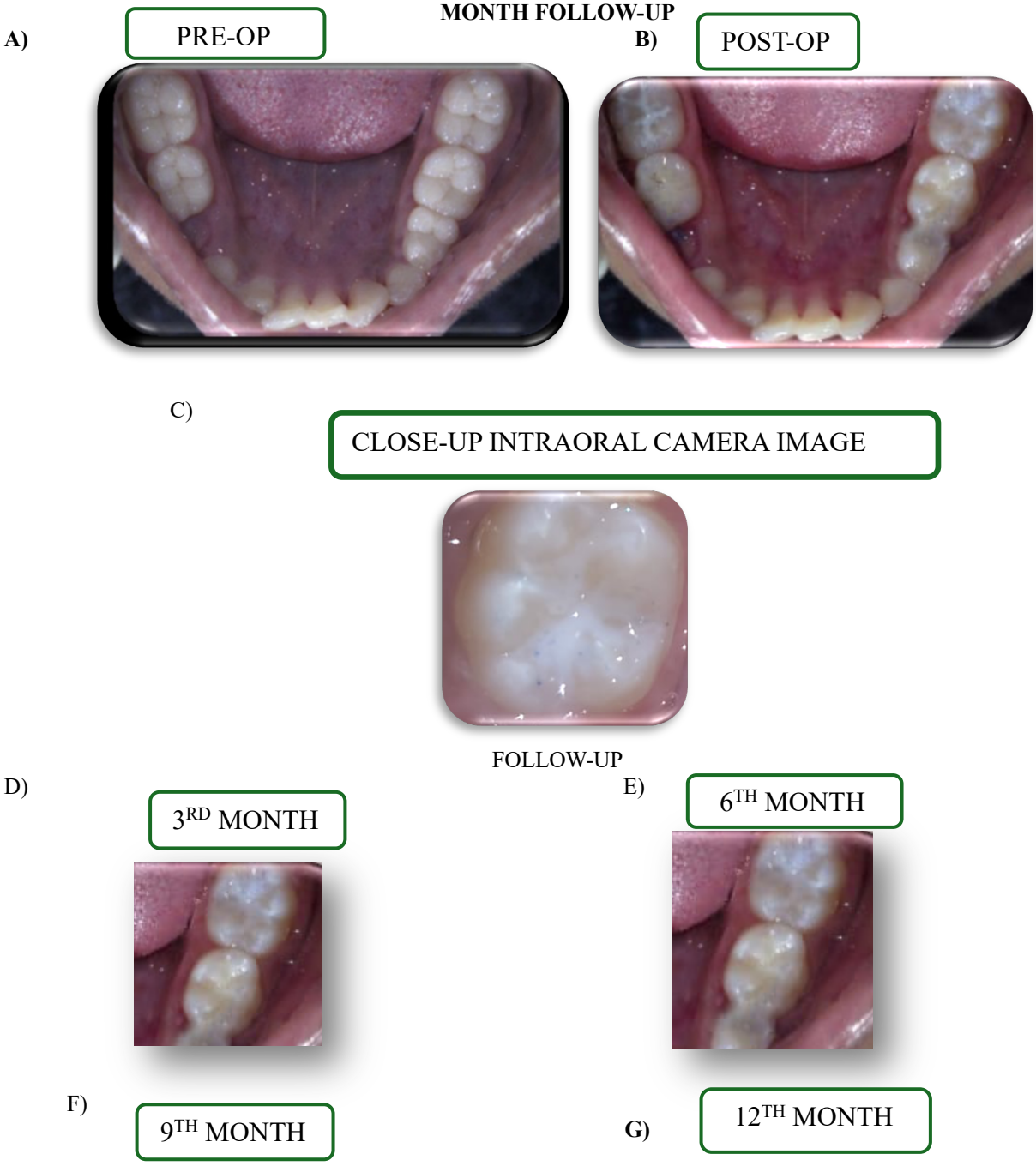


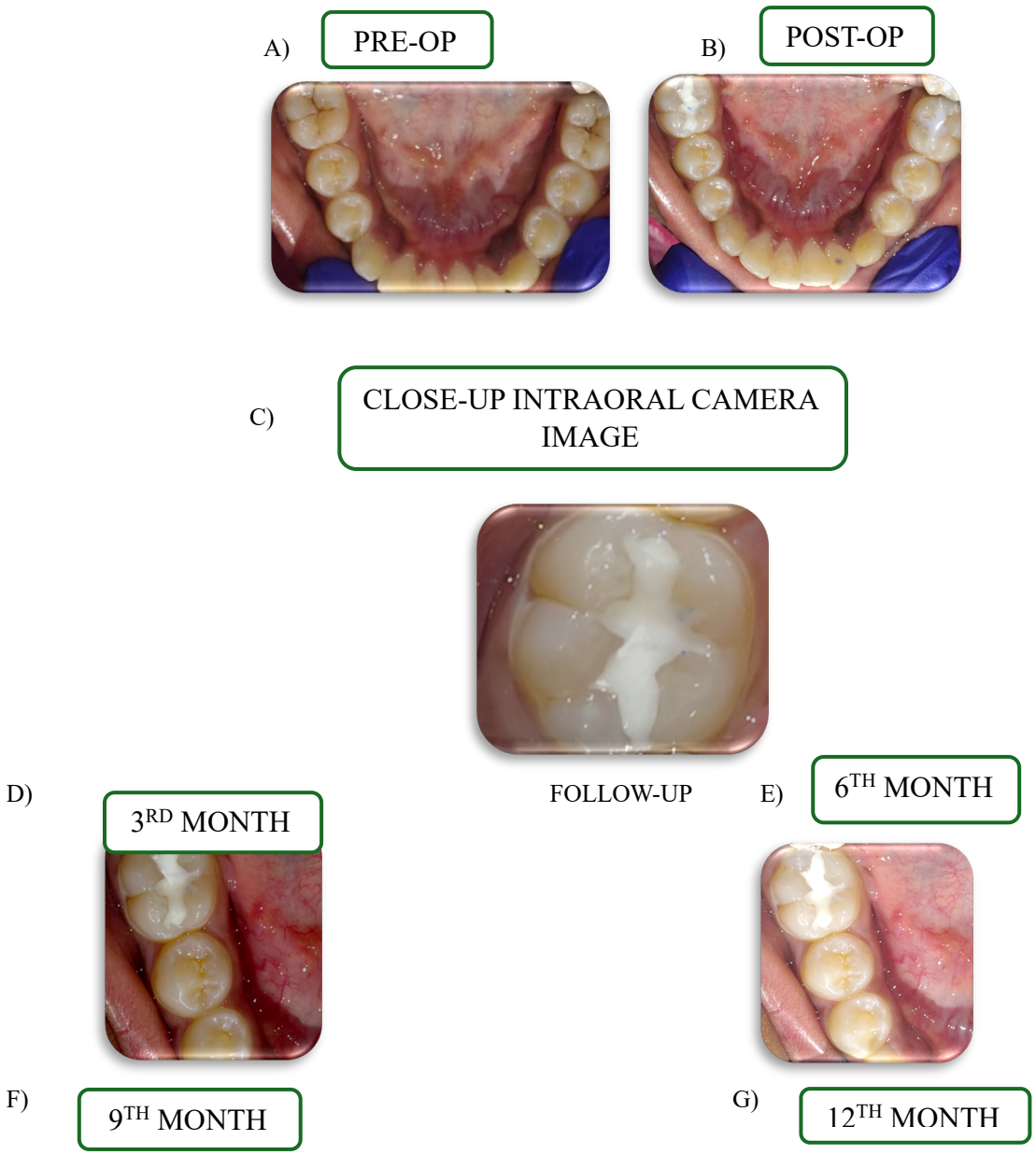
Table 5- Comparison of 'Modified Simenson's Criteria - Retention'

			GROUPS			Total	X^2 Value	P Value (Between group)
			GROUP A	GROUP B	GROUP C			
After	0	Count	38	38	38	114	-	-
		%	100.0%	100.0%	100.0%	100.0%		
3 months	0	Count	37	36	36	109	0.77	0.68
		%	97.4%	94.7%	94.7%	95.6%		
	No follow-up	Count	1	2	2	5		
		%	2.6%	5.3%	5.3%	4.4%		
6 months	0	Count	37	36	36	109	0.77	0.68
		%	97.4%	94.7%	94.7%	95.6%		
	No follow-up	Count	1	2	2	5		
		%	2.6%	5.3%	5.3%	4.4%		
9 months	0	Count	27	30	29	86	1.24	0.87
		%	71.1%	78.9%	76.3%	75.4%		
	1	Count	5	5	5	15		
		%	13.2%	13.2%	13.2%	13.2%		
	3	Count	1	0	1	2		
		%	2.6%	0.0%	2.6%	1.8%		
	No follow-up	Count	5	3	3	11		
		%	13.2%	7.9%	7.9%	9.6%		
12 months	0	Count	25	30	26	81	3.11	0.54
		%	65.8%	78.9%	68.4%	71.1%		
	1	Count	4	1	3	8		
		%	10.5%	2.6%	7.9%	7.0%		
	3	Count	4	4	6	14		
		%	10.5%	10.5%	15.8%	12.3%		
	No follow-up	Count	5	3	3	11		
		%	13.2%	7.9%	7.9%	9.6%		
Chi Square test			21.98	17.98	20.87			
P Value (Within group)			0.0001*	0.0001*	0.0001*			

Complete retention (100%) was observed in all groups at baseline. At 3 and 6 months, high and comparable retention rates were noted (GROUP A: 97.4%; GROUP B and C: 94.7%) with no significant intergroup differences ($p > 0.05$).

At 9 and 12 months, a gradual decline in retention was observed in all groups; however, intergroup differences remained statistically non-significant at all intervals ($p > 0.05$).Intragroup comparison showed a statistically significant decline in retention over time in all groups ($p < 0.0001$) as showed in Table 5.

FIGURE 5: **GROUP-C SEALANT GROUPA)PRE-OPB)POST-OPC)CLOSE-UP INTRAORAL CAMERA IMAGE D)3RD MONTH FOLLOW-UP E)6TH MONTH FOLLOW-UP F)9TH MONTH FOLLOW-UP G)12TH MONTH FOLLOW-UP**



DISCUSSION

Dental caries remains a major global health challenge in developing countries such as India, particularly among children and adolescents. Occlusal caries in permanent molars are commonly observed due to limited availability of preventive care and increased consumption of sugary foods. Pit and fissure sealants act by forming a protective barrier, preventing bacterial colonization and nutrient diffusion. Their long-term effectiveness depends on retention, marginal integrity, and prevention of secondary caries.

The present study assessed and compared glass ionomer–based, fluoride-releasing resin-based, and nano-silver reinforced sealants over a 12-month period.

RETENTION RATE

Retention is the most critical determinant of sealant success. At 6 months, high retention was observed in all groups with no statistically significant intergroup differences ($p > 0.05$). Glass ionomer sealants demonstrated 97.4% retention, exceeding the 86.1% reported by Edith G. Sly et al.[30], although lower values were reported by Ghosh D et al.[33]. Fluoride-releasing sealants showed 94.7% retention, higher than Ankita Baheti S et al.[12] and Mathew G et al.[34]. Nano-silver sealants demonstrated comparable retention, indicating that nanoparticle incorporation did not compromise bonding.

At 12 months, retention declined in all groups. Fluoride-releasing sealants showed the highest retention (78.9%), comparable to Ankita Baheti S et al.[12], Mathew G et al.[34], and Helen Schill et al.[22]. Glass ionomer sealants showed 65.8% retention, lower than Edith G. Sly et al.[30] but higher than Amara Nazir et al.[26]. Nano-silver sealants demonstrated 68.4% retention; however, Svetha et al.[31] reported higher retention for nano-silver sealants compared to fluoride-releasing sealants. Overall, fluoride-releasing sealants demonstrated superior long-term retention.

MARGINAL INTEGRITY

Marginal integrity is essential for preventing microleakage and secondary caries. At 6 months, high marginal integrity was observed, consistent with Edith G. Sly et al.[30] and Helen Schill et al.[22], with no significant intergroup differences ($p > 0.05$).

At 12 months, marginal integrity decreased in all groups. Fluoride-releasing sealants showed the highest marginal integrity (78.9%), followed by nano-silver (68.4%) and glass ionomer sealants (65.8%). These findings differ from Svetha et al.[31], who reported better performance of nano-silver sealants. The decline may be attributed to polymerization shrinkage, thermal cycling, and occlusal stresses.

CARIES OCCURRENCE

No secondary caries were observed in any group over the 12-month period. This differs from findings by Edith G. Sly et al.[30] and Mathew SR et al.[10], who reported caries development. Nano-silver sealants demonstrated promising antibacterial effects, supported by Enid Karina Salas-López et al.[34]. Biocompatibility studies by Martínez-Gutiérrez et al.[36] also support their clinical safety.

SEALANT LOSS

Sealant loss increased over time in all groups. Fluoride-releasing sealants showed complete loss in 4/38 teeth, comparable to Helen Schill et al.[22] and lower than Mathew G et al.[32], while Ankita Baheti S et al.[12] reported no loss. Glass ionomer sealants also showed 4/38 complete loss, lower than Amara Nazir et al.[26] and Edith G. Sly et al.[30], with partial loss comparable to Mathew SR et al.[10]. Nano-silver sealants showed higher loss (1 tooth at 6 months and 8 at 12 months), though no caries developed, indicating continued protection.

Within-group comparisons showed a statistically significant decline in retention and marginal integrity over time ($p < 0.0001$), while intergroup differences remained non-significant ($p > 0.05$).

LIMITATIONS AND FUTURE SCOPE

The study is limited by a small sample size, short follow-up period, lack of high caries-risk assessment, absence of fluoride release analysis, and no microbial evaluation. Future studies should include longer follow-up, evaluation of antibacterial efficacy, optimal nanoparticle concentration, and cost-effectiveness.

Within the limitations of the study, fluoride-releasing sealants demonstrated superior retention and marginal integrity, while nano-silver sealants showed promising antimicrobial potential. All three materials were effective in maintaining a caries-free status over the 12-month period.

CONCLUSION:

Within the limitations of the present study, all three restorative materials (GROUP A, GROUP B, and

GROUP C) demonstrated comparable clinical performance over the 12-month follow-up period, with no statistically significant intergroup differences ($p > 0.05$).Fluoride-releasing sealants showed relatively superior performance, followed by nano-silver reinforced and glass ionomer–based sealants, particularly in terms of retention and marginal integrity.All materials were effective in preventing secondary caries, with no caries observed in any group throughout the study period.Overall, all three pit and fissure sealants performed satisfactorily and exhibited similar effectiveness in maintaining retention, marginal integrity, and caries prevention over one year.

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