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Original Article

Performance Of Flowable Giomer Versus Nanofilled Flowable Composite With Or Without Giomer Coat In Conservative Occlusal Cavities: 18 Months Randomized Clinical Trial

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Abstract

Aim: This study was conducted to evaluate clinical performance of flowable giomer and flowable resin composite coated with S-PRG in comparison to flowable resin composite as a preventative resin restoration in patients requiring minimally invasive simple class I cavities in permanent molars over 18 months test period.
Subjects and methods: Patients with occlusal cavities in permanent molars with ICDAS score 2, were randomly assigned into three groups (n=14 each group, total =42). Group A1 received Flowable giomer, group A2 received Flowable Resin Composite with S-PRG coat applied biannually and group A3 (control) received flowable resin composite. All materials were utilized using the manufacturers' instructions. Evaluation of restoration was carried out using FDI criteria and probes. Incidence of new carious lesions was evaluated using DIAGNOdent pen. All outcomes were measured at baseline (1 week after placement), after 6, 12, and 18 months.
Results: DIAGNOdent scores showed significant intragroup improvements over time, while intergroup differences emerged at later follow-ups. Based on FDI criteria, no significant differences were found between materials. All restorations demonstrated 100% success and survival at 18 months.
Conclusion: All tested materials showed similar clinical performance and absence of incidence of new carious lesions after 18 months follow-up.

Keywords: Giomer, PRR, Minimally Invasive, Occlusal caries, Barrier coat, Flowable

Introduction

Dental caries remains the most prevalent global disease and a significant public health concern. The World Health Organization defines it as a localized pathological process caused by external factors, leading to enamel demineralization, structural damage, and cavity formation. Its progression is influenced by genetic, behavioral, environmental, and personal factors such as enamel composition, salivary flow, and plaque accumulation **(Mazurkiewicz et al., 2023).** Occlusal caries is considered particularly common due to the complex anatomy of pits and fissures, which are susceptible to plaque retention and hinder cleaning **(Ng et al., 2023).**

To preserve tooth structure, maintain ideal esthetics, and aid in caries prevention and arrest, minimally invasive class I restorations are considered ideal **(Liu et al., 2019; Shaalan et al., 2017)**. The process of lesion removal, followed by the placement of flowable restorative material, is termed preventive resin restoration (PRRs) **(Almtere et al., 2022)**. The success of PRRs is directly dependent on both the physical and mechanical properties of the restorative material; therefore, flowable composites are favored as they closely adapt to the cavity walls **(Dukić et al., 2021; Baroudi & Rodrigues, 2015).**

Novel materials such as nanofilled composites and giomers are enhancing the long-term performance of PRRs due to their desirable mechanical properties, versatility, and simplicity. Additionally, fluoride-releasing materials such as giomers are gaining attention as they promote remineralization and prevent secondary caries **(Hendam et al., 2025; Ozer et al., 2021).** Giomers combine the desirable properties of glass ionomers and resin composites; the release of fluoride can be attributed to the presence of S-PRG fillers while maintaining the esthetic and mechanical properties of resin composite **(Elmokanen & Gad, 2024).**

To prevent caries development and minimize future invasive restorations, S-PRG barrier coats are used. Release of fluoride, aluminum, borate, strontium, sodium, and silicate ions from the barrier coat promotes enamel remineralization **(Moecke et al., 2022; Spinola et al., 2020).** Additionally, the ions improve enamel hardness and stabilize the oral environment by neutralizing the acidic medium **(Mahmoud et al., 2025; Imazato et al., 2023).**

Clinical performance differs from in-vitro testing as it evaluates long-term performance and therefore, is used to evaluate the performance of restorative material in the oral cavity **(Ahmed et al., 2024).** Due to the insufficiency of evidence-based literature, this randomized clinical trial was conducted to assess the performance of giomer-based and giomer-coated flowable composites in comparison to conventional flowable composites in PRRs.

Materials and Methods

A. Materials:

Table (1): Materials name, category, composition, manufacturer, website and lot number:

B. Methods:

Eligibility criteria:

Eligibility criteria of participants:

Inclusion criteria:

- Age (19-40) **(Shaalan and Abou-Auf 2021)**
- Unilateral or Bilateral small Class I carious lesions
- Patients with high caries risk assessment

Exclusion criteria:

- Existing systemic diseases
- Severe medical complications
- Allergy history concerning methacrylates
- Pregnancy
- Heavy smoking
- Evidence of severe bruxism, clenching or temporomandibular joint disorders
- Patients with salivary dysfunction

Eligibility criteria of teeth:

Inclusion criteria:

- Small Class I carious lesion in occlusal pits and fissures ICDAS score of 2 **(Shaalan 2023)**
- Teeth should be in proper occlusion without missing adjacent or opposing teeth **(Dukić et al., 2021)**

Exclusion criteria:

- Presence of existing occlusal restoration
- Periapical or pulpal pathology
- Tooth hypersensitivity
- Possible prosthodontic restoration of teeth
- Endodontically treated teeth
- Severe periodontal affection

Table (1): Materials name, category, composition, manufacturer, website and lot number:

MATERIAL NAME	CATEGORY	COMPOSITION	MANUFACTURER AND WEBSITE	LOT NUMBER
Meta Etchant	Acid etchant	Phosphoric acid 37% by weight, distilled water <60% by weight, Xanthan gum 1-5% by weight and blue pigment 1-5% by weight	Meta Biomed, South Korea, Korea (https://www.meta-biomed.com/bbs/board.php?bo_table=dental&wr_id=27)	**MET2412231**
All-Bond Universal ®	Universal Adhesive	10-MDP, phosphoric acid ester monomer, Bis-GMA, HEMA, ethanol, water, initiators	Bisco; Schaumburg, IL, USA (https://global.bisco.com/all-bond-universal-/)	**2400001116**
Nano SPRG reinforced flowable composite (Shofu™ Beautifil Flow Plus X)	Flowable Resin Composite	Aluminofluoro-borosilicate glass 50-60% by weight, Bis-GMA 10-20% by weight, TEGDMA 5-20% by weight, Bis-MPEPP 5-15% by weight, Silane coupling agent 5- 10% by weight, SiO2 0.5-5% by weight, Al2O3 1-5% by weight and Colorant.	Shofu Dental Corp, Japan (https://www.shofu.com/ en/product/beautifil-flow-plus-x/)	**102220**
Shofu™ PRG Barrier Coat	Barrier Coat	Active: Phosphonic acid monomer 10-40% by weight, Methacrylate monomer 20-30% by weight Bis- MPEPP, Carboxylic acid monomer, TEGDMA and Reaction initiator Base: Glass powder 50-60% by weight, Pure water, Methacrylate monomer	Shofu Dental Corp, Japan (https://www.shofu.com/ en/product/prg-barrier- coat/)	**032318**
Conventional Nanofill flowable resin composite (Filtek™ Z350XT Flowable)	Flowable Resin Composite	The inorganic filler loading is approximately 65% by weight. Fillers: 75nm non agglomerated/non aggregated silica nanofiller, and 5-10 nm zirconia nanofiller and 5-20 nano cluster of agglomerated zirconia/silica with size range is 4 to 11 microns. Resin is formulated with the methacrylate resin monomers BisGMA, TEGDMA and Bis-EMA.	3M ESPE, St. Paul MN, USA (http://www.3m.com/3M/en_US/dental- us/support)	**N298527**
PEDRA POMES®	Abrasive pumice slurry	Pumice Stone: low-density, extra-fine abrasive	Maquira Dental Products, Maringá, Brazil (https://maquira.com.br/en/produto/pumice-stone/)	**720821**

Abbreviation	**Full form**
Bis-GMA	**Bisphenol A-Glycidyl Methacrylate**
HEMA	**2-Hydroxyethyl Methacrylate**
TEGDMA	**Triethylene Glycol Dimethacrylate**
Bis- EMA	**Ethoxylated Bisphenol A Dimethacrylate**
Bis-MPEPP	**Bis(4-methacryloxy-polyethoxyphenyl) propane**

Study design and Grouping:

A double-blind randomized clinical trial with three parallel groups (n = 14 per group, total 42 teeth). Group A1 received flowable giomer, Group A2 received flowable resin composite with biannual S-PRG coat, and Group A3 (control) received flowable resin composite. Evaluations were at baseline (T0), 6 (T1), 12 (T2), and 18 months (T3).

Recruitment:

Simple random sampling was conducted at the Conservative Dentistry Department, Cairo University, where patients were screened, examined, and diagnosed.

Randomization:

Sequence generation:

Simple randomization was performed using a computerized number generator (www.random.org) to assign numbers from 1 to 42 into three groups with a 1:1:1 allocation ratio, following standard randomized trial protocols.

Implementation

Treatment assignment followed sequential number allocation, as illustrated in **Figure (1).**

Preoperative Assessment

Teeth were cleaned using a slow-speed handpiece and pumice slurry, then rinsed to remove residual pumice **(Prabahar et al., 2022)**. DiagnodentPen was then used to determine the extent of caries and ensure that the readings were not influenced by the biofilm, thus preventing false results.

Occlusal Assessment Preoperatively

Class I cavity preparations, with facio-lingual width not exceeding ¼ intercuspal distance, away from functional areas which were determined using articulating paper. **(Shaalan et al., 2017).**

Cavity Preparation

Cavity preparation was carried out using a number 330 bur (Mani, Inc., Japan) in a high-speed handpiece under copious irrigation**.** To standardize cutting efficiency and minimize the effects of bur dulling and wear, each bur was used a fixed number of times, specifically twice, based on the protocol described by **Lisiecka (2018).** To ensure standardization of the cavity design, only teeth with an ICDAS score of 2 were included in the study and complete caries removal was carried out.

Material Application

Application of etch and rinse adhesive technique

Teeth were etched for 30 seconds with 37% phosphoric acid gel **(Taşan and Ceran 2024)** then rinsed thoroughly. The bonding agent was applied in two consecutive layers as per the manufacturer's instructions. It was then light cured for 20 seconds using an LED curing unit (i Led Guilin Woodpecker Medical Instrument Co., Ltd., China), positioned at nearly zero distance from the surface.

Application of flowable resin restorative material

Restorative materials were delivered directly from the dispensing tip into the cavity and used according to manufacturer instructions**.** Sharp explorer was used to manipulate the materials into pits and fissures and to remove any air bubbles on the surface and to obtain a uniform flow of the material **(Reddy et al., 2015)** followed by curing according to manufacture instructions using LED light cure at almost zero distance.

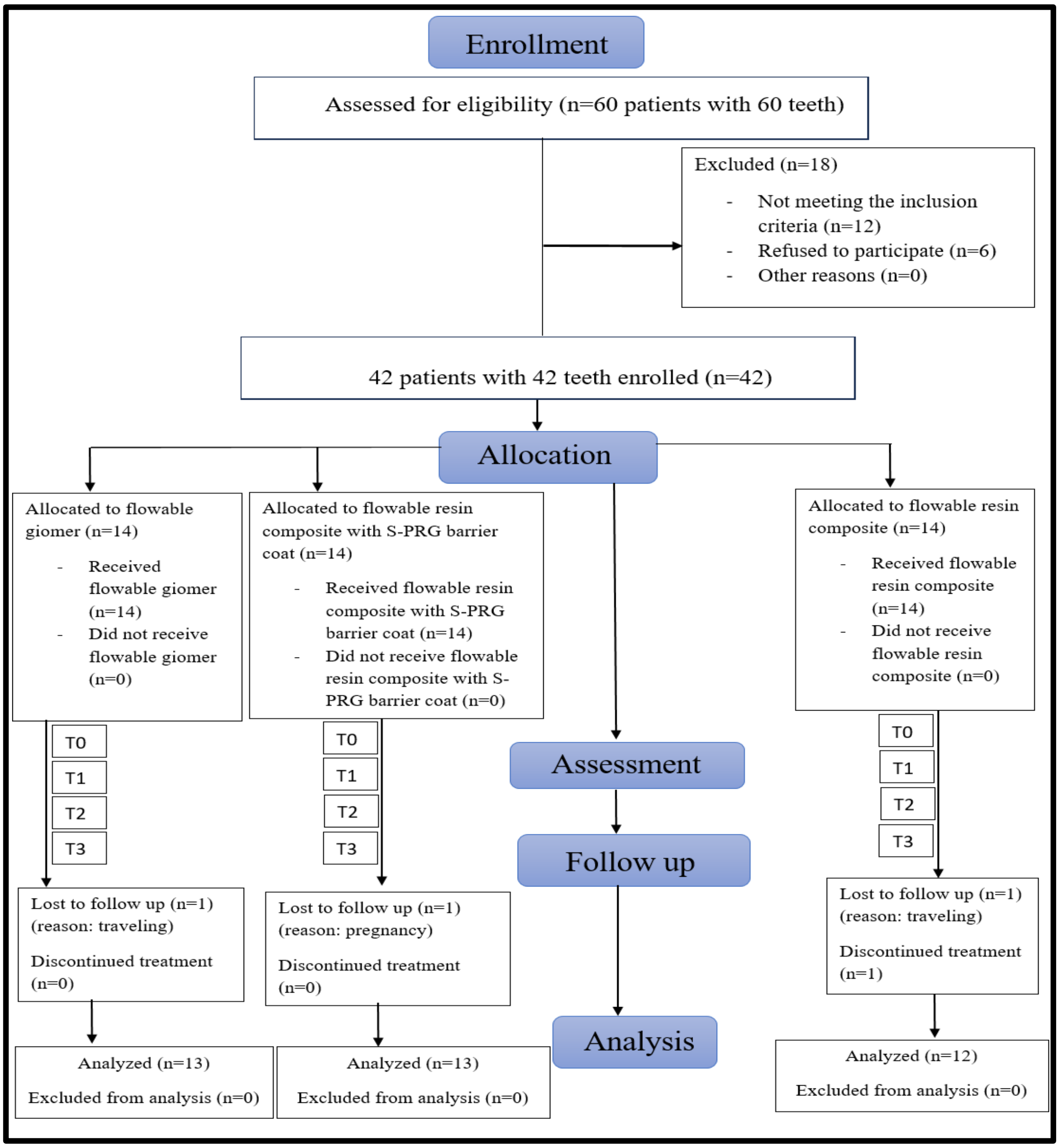


Figure (1): Flow Chart of the Study

Application of S-PRG barrier coat

The S-PRG barrier coat was applied to restorations in the intervention group treated with conventional flowable resin composite by mixing Base and Active components, applying a thin layer within two minutes, and light-curing for 10 seconds. The uncured layer was removed with a damp cotton roll. Patients were advised to avoid stain-causing foods for three days. The coating was reapplied at the 6-month follow-up using the same protocol (**Shofu manufacturer instructions**).

Clinical evaluation of the Preventative resin restoration (Outcome Assessment):

Primary outcome (Fracture and retention of material):

Fracture and retention were evaluated one week after placement of restorative material and at each recall appointment using visual-tactile examination. Teeth were air-dried and assessed under a dental operating light, using mirrors and FDI probes **(Hickel et al. 2010)**.

Secondary outcome (Marginal adaptation, occlusion and wear, form and contour, dental hard tissue defects at restoration margins and postoperative hypersensitivity/pulp status):

Each subgroup of the secondary outcome was assessed using FDI probes **(Hickel et al,. 2010).** The scores were compared to assess the relative success or failure of the restoration.

Secondary outcome (Incidence of new carious lesions)

Incidence of new carious lesions were assessed by the usage of DIAGNOdent pen **(Jaafar et al., 2020).** The probe was then gently applied to the tooth surface at multiple angles, particularly into pits and fissures, without pressure, and the highest value observed was recorded as the reading for that site.

Results:

DIAGNOdent score (within different follow-up periods):

Intergroup comparison showed no significant difference at baseline ($P = 0.9436$), but significant differences emerged at 6, 12, and 18 months ($P < 0.05$). Intragroup comparisons revealed a significant change in DIAGNOdent scores over time in all groups ($P < 0.00001$) **(Table 2)**.

FDI criteria

Intergroup comparisons among the three materials revealed no statistically significant differences across all evaluated clinical criteria at baseline, 12 months, and 18 months ($P>0.05$). A statistically significant difference was only observed for occlusion and wear at 6 months ($P<0.05$). Intragroup comparisons showed no statistically significant changes over time within any of the three groups. Additionally, no increased risk of failure (defined as scores 4 and 5) was identified for flowable giomer or flowable composite with S-PRG compared to the conventional flowable composite after 18 months (RR=0.92, 95% CI: 0.01983 to 43.4892; P=0.9699)) **(Table 3 & Figures 2-4).**

Success rate:

After 18 months, all restorations in all groups were successful, no restorations showed score 4 and 5. There was no risk of failure (score 4 and 5) of flowable giomer and flowable composite + S-PRG when compared to flowable composite after 18 months (RR= 0.92 (95% 0.01983 to 43.4892; P = 0.9699)). Kaplan-meier analysis was used to obtain survival curves, comparison of survival curves was performed using Logrank test, there was no statistically significant difference between materials (P = 1.0000). **(Figure 5)**

Figure (2): Application of giomer filled flowable to tooth #47

a: Preoperatively b: Immediately post-operatively c: Follow-up after 18-months

Figure (3): Application of conventional resin-based nano-filled flowable composite and biannual application of S-PRG barrier coat to tooth #27

a: Preoperatively b: Immediately post-operatively c: Follow-up after 18-months

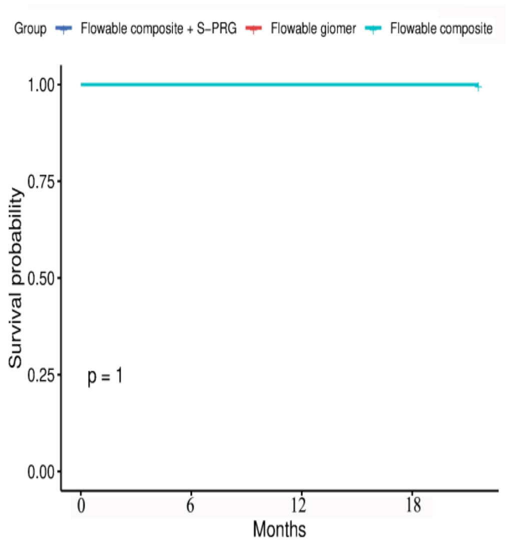
Figure (4): Application of conventional resin-based nano-filled flowable composite to tooth #37

a: Preoperatively b: Immediately post-operatively c: Follow-up after 18-months

Follow-up	**A1**		**A2**		**A3**		P value
	Median	Range	Median	Range	Median	Range	
Baseline	17[a]	17 to 19	18[a]	17 to 18	17[a]	17 to 19	P = 0.9436
6 months	6[Bb]	0 to 10	6[Bc]	0 to 8	8[Ac]	7 to 11	P = 0.0446*
12 months	6[Bb]	0 to 7	6[Bc]	0 to 9	8[Ac]	8 to 10	P = 0.0126*
18 months	6[Bb]	0 to 7	9[Ab]	5 to 11	9[Ab]	8 to 12	P = 0.001*
P value	P <0.00001*		P <0.00001*		P <0.00001*		

Table (2): Median and values for DIAGNOdent scores showing the intergroup comparison between materials within each follow-up and intragroup comparison within each material between different follow-up periods.

Figure 5: Survival analysis of flowable giomer, flowable composite + S-PRG and flowable composite in minimally invasive occlusal restorations after 18 months



Discussion:

Restorative dentistry is shifting from the traditional “drill and fill” approach to a preventative model focused on conservation. PRRs play a crucial role in this transition and support the “seal and heal” philosophy that promotes early intervention and long-term oral health **Pandey (2024)**.

According to **Baroudi & Rodrigues (2015),** flowable composites are increasingly favored due to their superior handling characteristics, low viscosity, and ability to adapt intimately to cavity walls, therefore enhancing marginal integrity and decreasing microleakage. Advancements in filler technology have improved the mechanical properties of flowable composites, making them comparable to those of packable composites. As a result, their indications have broadened, including use in cases where the isthmus width is less than half the intercuspal distance **Lawson et al., (2015). Shaalan and Abou Auf (2021)** have noted that in conservative occlusal cavities, flowable composites are frequently utilized.

Imazato et al., 2023 stated that their antimicrobial, desensitizing, and remineralizing properties have caused bioactive materials to gain popularity. Additionally, **Ogawa et al,. 2022** emphasized that their interaction with the tooth structure, mechanical, and esthetic properties align with minimally invasive approaches. However, **Aliberti et al,. 2025** stated that despite successful in-vitro studies, clinical evidence remains lacking.

The reliability of ICDAS II in detecting occlusal caries within the outer half of enamel ensured that accurate lesion selection was implemented throughout the study. Therefore, to identify cases where bioactive materials may offer therapeutic benefits, only ICDAS score 2 lesions were included **(Diniz et al., 2009).**

Participant-related variables were standardized to enhance the validity of the study. To ensure the long-term success of restorative treatments, achieving and maintaining optimal occlusion is essential. This ensures

Outcome		Follow up / Group	T0 (Baseline)			T1 (6 months)			T2 (12 months)			T3 (18 months)			P-Value
			Score			Score			Score			Score			
			1	2	3	1	2	3	1	2	3	1	2	3	
Primary	**Fracture and retention of material**	**A1**	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)	0.392
		A2	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)	0.392
		A3	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	12 (100%)	0 (0%)	0 (0%)	0.112
Secondary	**Marginal adaptation**	**A1**	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)	0.392
		A2	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)	0.392
		A3	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	12 (100%)	0 (0%)	0 (0%)	0.112
	Occlusion and wear	**A1**	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	9 (69.2%)	3 (23.1%)	1 (7.7%)	0.392
		A2	14 (100%)	0 (0%)	0 (0%)	9 (64.3%)	5 (35.7%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	13	0 (0%)	0 (0%)	0.392
		A3	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	12 (100%)	0 (0%)	0 (0%)	0.112
	Form and contour	**A1**	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	13 (100%)	0 (0%)	0 (0%)	0.392
		A2	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	13 (100%)	0 (0%)	0 (0%)	0.392
		A3	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	12 (100%)	0 (0%)	0 (0%)	0.112
	Dental hard tissue defects at restoration margins	**A1**	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	13 (100%)	0 (0%)	0 (0%)	0.392
		A2	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	13 (100%)	0 (0%)	0 (0%)	0.392
		A3	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	12 (100%)	0 (0%)	0 (0%)	0.112
	Postoperative hypersensitivity/ pulp status	**A1**	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	13 (100%)	0 (0%)	0 (0%)	0.392
		A2	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0	14 (100%)	0	0	13 (100%)	0 (0%)	0 (0%)	0.392
		A3	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0 (0%)	0 (0%)	14 (100%)	0	0	12 (100%)	0 (0%)	0 (0%)	0.112

Table (3): FDI criteria scores of each material at different follow-up periods occlusal harmony, functional balance, minimizes wear and fracture, thus preventing occlusal trauma **(Aldowish et al., 2024)**. The age group of 18-40 was selected as it represents individuals with fully erupted dentition and minimal age-related or systemic complications, better periodontal health, higher compliance with follow-ups, and thus offering more predictable outcomes **(Reda et al., 2023).** To enhance diagnostic accuracy and clinical decision-making, this study combined both visual-tactile assessment with fluorescence-based methods. To assess the restorations from both biological and mechanical aspects, both the FDI criteria and DIAGNOdent Pen were utilized in the study. The DIAGNOdent pen detects early mineral loss that can be quantified by the emission of laser fluorescence **(Yehua et al., 2024; Lussi et al., 2001). Adly et al., 2025** concluded that to ensure consistent lesion selection dual diagnostic strategy should be implemented.

Hickel et al., (2023) recommended the usage of the FDI criteria as the ordinal grading scale detects minor subtle changes that may be overlooked by binary systems such as the USPHS criteria. A scoping review conducted by **Marquillier et al., (2018)**, concluded that the FDI criteria is practical and standardizied. Additionally, **Mesinger et al., (2023)** emphasized the reliability and efficiency of the criteria in assessing direct and indirect restorations, however, highlighting that examiner training and calibration is crucial.

A laser of wavelength 655nm is emitted from the DIAGNOdent pen resulting in the production of numerical values ranging from 1-99 based on the principle that carious tissues fluoresce more than sound tissues **Abdelaziz (2023). Lussi et al., (2001)** claimed that a major drawback is the susceptibility to interference from stains, deposits or calculus, which can lead to false positive results. Therefore, it may be less effective in the detection of incipient enamel caries.

As recommended by **Liu et al,. (2019)** and **Shaalan et al,. (2017),** minimally invasive principles were followed to preserve maximum tooth structure by limiting the facio-lingual width to one-quarter of the intercuspal distance. A 330 pear-shaped bur ensured consistent cavity dimensions throughout the trial. To maintain cutting efficiency and reduce variation in sharpness, each bur was discarded after two uses, as recommended by **Lisiecka (2018). Lawson et al., (2015)** emphasized the importance of maintaining bur integrity to reduce iatrogenic damage and preserve tooth structure and cavity morphology.

Flowable giomer (Beautifil Flow Plus X, Shofu Inc.) was utilized in the first group as it includes S-PRG technology. Despite the negligible degradation that occurs with S-PRG, it has been noted that due to the synergistic properties of the six-ion release, remineralization, antibacterial properties, and acidic resistance are anticipated **(Imazato et al., 2023; Yamamoto et al., 2021**. **Spinola et al., 2020; Nomura et al., 2018).**.

The second group received conventional nano-filled flowable composite (Filtek Z350 XT Flowable, 3M), due to their documented mechanical strength and esthetic performance as stated by **Shaalan and Abou Auf (2021)**, followed by biannual applications of an S-PRG barrier coat. According to **Imazato et al., 2023** tooth enamel is protected from acidic attacks due to the release of fluoride and strontium ions.

The third and final group (control) received nanofilled flowable composite (Filtek Z350 XT Flowable, 3M) as it represents the current gold standard for minimally invasive posterior restorations due to its high filler load, polishability, longevity and decreased modulus of elasticity **(Shaalan & Abou Auf, 2021; Lawson et al., 2015).**

After study completion, all materials tested excelled with a 100% survival rate across the tested parameters in the FDI criteria, with no statistically significant differences among groups. Studies by **Dukić et al., (2021) and Lawson et al., (2015)** support these findings and concluded that flowable composites are suitable restorative materials for conservative occlusal cavities, when properly placed. Minor wear (score 2) was observed in some giomer restorations, aligning with **Mu et al. (2020)**, who noted slightly lower wear resistance in giomers compared to universal composites.

Regarding retention, all groups maintained excellent scores, echoing findings from **Toz-Akalin et al. (2024), Ozer et al. (2022), and Abdel-karim et al. (2014)**, though **Toz-Akalin et al. (2023)** reported a single case of giomer retention failure. Marginal adaptation remained stable, consistent with **Dukić et al. (2021), Lawson et al. (2015), and Rocha Gomes Torres et al. (2014)**, however **Celik et al. (2010)** reported poor marginal adaptation in some flowable composites, potentially due to the absence of acid etching step. **Marquillier et al. (2018)** cautioned that the FDI system, while sensitive, may not detect subtle margin issues in short-term or small-sample studies.

No significant differences between groups for occlusion, wear, anatomical form, or hard tissue defects, supporting the results of **Badr et al. (2021) and Shaalan and Abou-Auf (2021),** who observed stable performance over two years. However, **Mu et al. (2020)** reported two wear patterns in a four-year study however they were within acceptable ADA limits.

The study identified a statistically significant decrease in the integrity of the S-PRG Barrier Coat at six months, aligning with manufacturer guidelines. **Shofu Inc. (2019)** notes that daily brushing gradually removes the coating, additionally, **Shofu Dental Asia-Pacific Pte. Ltd. (2023)** states its protective effect lasts up to six months. This suggests the observed wear corresponds with the material's expected lifespan.

Over time significant score reduction was noted with the DIAGNOdent evaluation in the giomer and S-PRG coated groups, supporting the claim of potential preventive benefits through remineralization or caries suppression. Comparable results in studies conducted by **Mostafa et al. (2023), Yamamoto et al. (2021), and Suzuki et al. (2015),** and credited these benefits to the therapeutic action of S-PRG ions.

The results of the study demonstrate that biannual application of S-PRG coat, even when used with conventional composites, may have a measurable biological effect. This suggests that bioactivity can be achieved through topical application rather than relying on the properties of bulk materials **Dimopoulou and Baysan (2024)**. Studies by both **Shaalan et al., (2017) and Lawson et al., (2015)** support the current study's findings that active caries management and long-term successful clinical results can be anticipated when minimally invasive cavity designs are paired with modern materials.

Conclusion :

1. All tested restorative materials demonstrated excellent clinical performance over the 18-month evaluation period.
2. Bioactive materials showed superior preventive effects as evidenced by significant reductions in DIAGNOdent scores, suggesting enhanced remineralization potential and caries suppression compared to conventional composites.
3. The biannual application of S-PRG coating is mandatory to provide measurable biological benefits even when used with conventional composites

Conflict of Interest:

No conflict of interest.

Funding:

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Ethics:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability:

The data supporting this current study are available from the corresponding author on reasonable request.

Clinical trial registration:

The protocol for this study was registered on clinicaltrials.gov, under ID: NCT06097143

Credit statement:

Author 1: contributed to the study's concepts, design, intellectual content, literature search, data acquisition, and manuscript preparation, editing, and review.

Author 2: contributed to the study's concepts, design, intellectual content, literature search, data acquisition, and manuscript preparation, editing, review, and served as the principal investigator.

Author 3: contributed to the study's concepts, design, intellectual content, literature search, data acquisition, and manuscript preparation, editing, and review.

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