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Comparison in the Degree of Staining Between Four Different Composites Used Regularly For Attachments In Aligner Therapy- A Pilot Study

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Abstract:
Background*: With the increasing demand for esthetic orthodontic solutions, clear aligner therapy has gained popularity due to its discreet appearance. However, the use of flowable composite attachments with aligners presents challenges, particularly in maintaining color stability under various staining conditions. Limited studies have evaluated the staining resistance of bulk-fill flowable composites used for orthodontic attachments.*
Materials and Methods*: This study investigates the staining susceptibility of four bulk-fill flowable composites—Prime Dental Bulk Fill, Ivoclar Bulk Fill, Beautifil Bulk Fill, and Waldent Bulk Fill (all in shade A2)—commonly used for orthodontic attachments. A preliminary pilot study was conducted to refine the methodology, ensuring accurate spectrophotometric assessment and optimizing sample preparation. The main study utilized spectrophotometric analysis within the CIE Lab* color space to measure color changes. Statistical analysis was performed using one-way ANOVA to compare the staining resistance of the different composite materials.*
Results*: The spectrophotometric assessment revealed significant differences in staining resistance among the four composite materials. Some materials demonstrated better color stability over time, while others showed greater susceptibility to discoloration when exposed to common staining agents.*
Conclusion: *Prime composite showed the least staining, while Ivoclar exhibited the most discoloration among the tested materials. Material selection is crucial for maintaining esthetics in aligner therapy. Future research should explore enhanced composite formulations for better stain resistance.*
Keyword: *Clear aligner therapy, Esthetic orthodontics, Color stability, Orthodontic attachments, Spectrophotometric assessment*

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I. Introduction

Aligner treatment is an emerging orthodontic approach using a series of clear aligners to gradually shift teeth with controlled pressure (Papadimitriou et al., 2018; Weir, 2017). These aligners offer aesthetic appeal, comfort, and removability, facilitating better oral hygiene (Tamer et al., 2019; Miller et al., 2019). Attachments, typically composite-based, enhance treatment by aiding tooth movements like torque or rotation. However, attachment staining—categorized as extrinsic (surface stains) or intrinsic (within the material)—can affect aesthetics, caused by chromogenic bacteria, dietary factors, inadequate maintenance, or material type. Composite attachments are made of bulk-fill or flowable composites. Bulk-fill composites, with higher filler content (~75–80%), provide deeper curing and strength, whereas flowable composites (~55–65% filler) offer flexibility but higher shrinkage (Czasch & Ilie, 2013; Ilie & Hickel, 2011). Bulk-fill flowable composites (~65–75% filler) balance flowability and strength, proving effective in orthodontics for adhesion, occlusal buildups, and enamel protection (Moszner & Salz, 2016). They reduce chair time and improve esthetics but require careful handling to avoid polymerization issues. Despite some limitations, bulk-fill flowable composites have enhanced orthodontic workflows and treatment efficiency

II. Material And Methods

The study population included four groups of flowable bulk-fill composites. The sample size was set at four for each composite Four bulk fill flowable composite of brands are prime ,waldent, beautifil,,ivoclar of shade universal was used; 16 disc-shaped specimens of each composite were taken by cylindrical generators with a thickness of 2 mm and a diameter of 10mm similarly in a standard way. When taking the specimens,3D model of 2mm thickness and 10 mm diameter is taken impression with putty and the composites are filled and the specimens were then cured for 60s on both sides (120 s in total) by a 550 mW/cm? light cure device(Bonart Co Ltd). In the next step, the specimens were polished by silicon carbide paper discs (soflex-3M-ESPE-ultra-thin, USA) to minimize discoloration due to the surface roughness of the composites. The final thickness of the discs was 2 mm and all areas were measured with a caliper. In the next step, all specimens were kept in distilled water for 48 h for primary water absorption and completion of the polymerization process and proximity to oral conditions. Specimens of each type of composite were divided into eight groups.

Study Design: in vitro study

Study Location: Tagore dental college and hospital, Rathinamangalam, Chennai, India

Study Duration: August 2024 to January 2025.

Sample size:16 specimen.

Sample size calculation: The sample size was estimated on the basis of a pilot study
Group 1 ivoclar bulk fill composite
Group 2 waldent bulk fill composite
Group 3 prime bulk fill composite
Group 4 beautifil bulk fill composite

Inclusion criteria:
1. Only bulk-fill flowable composite resins were included in the study.
2. Composites of shade A2 were chosen to maintain uniformity.
3. Four specific brands—Prime Dental Bulk Fill, Ivoclar Bulk Fill, Beautifil Bulk Fill, and Waldent Bulk Fill—were included.
4. Disc-shaped specimens (2mm thickness, 10mm diameter) were standardized for all groups.
5. All specimens were light-cured using a 550 mW/cm² light cure device for a total of 120 seconds.
6. Specimens were polished with silicon carbide paper discs to minimize surface roughness.
7. Specimens were stored in distilled water for 48 hours before testing.
8. The study included exposure to coffee, turmeric, and coke solutions to evaluate staining potential.
9. All samples were measured for color stability using a reflective spectrophotometer under CIE Lab* color space parameters.

Exclusion criteria:
1. Any composite type other than bulk-fill flowable composites was excluded.
2. Composites of shades other than A2 were not considered to maintain uniformity.
3. Any specimen that did not meet the size and thickness criteria was excluded.
4. Specimens that were not cured according to the defined protocol were excluded.
5. Samples that were not polished with silicon carbide discs were not included in the study.
6. Specimens not stored in artificial saliva and distilled water under controlled conditions were excluded.
7. Samples that were not exposed to staining agents for the exact duration (40 hours total) were not considered.
8. Any staining agent other than turmeric, coffee, and coke was excluded from the study.
9. Samples with incomplete spectrophotometric measurements or missing data points were excluded from the final analysis.

III. Procedure Methodology

Table no 1

Group	Composite Material	Solution
1:1	Ivoclar	Artificial Saliva
1:2	Ivoclar	Staining Solution
2:1	Waldent	Artificial Saliva
2:2	Waldent	Staining Solution
3:1	Prime	Artificial Saliva

3:2	Prime	Staining Solution
4:1	Beautifil	Artificial Saliva
4:2	Beautifil	Staining Solution

Figure 1: Composites Included In The Study

1.Beautifil , 2.Waldent , 3.Prime , 4.ivoclar

The eight subgroups were immersed for 10 days , 4h a day ,40 h in total. The control group (1.1 ,2.1 ,3.1 ,4.1)20 hours in only articial saliva ,2 hours per day for 10 days .the Group (1.2 ,2.2 ,3.2 ,4.2)[20 hours in staining solutions cycle] ,15 hours staining medium [5 hours- turmeric medium,5hours– coffee medium, 5 hours – coke] and 5 hrs in artificial saliva .The control Group immersed in artificial saliva at 37°c for 10 days ,pH of beverages was measured before immersing. In addition, the specimens were cleaned with distilled water and a soft toothbrush for 30 s each time after removing them from the solution.

At the end of the 10th day, the specimens were transferred to a reflective spectrophotometer to measure the colour after the discoloration stage.

Statistical analysis

The ANOVA indicate that the p-value is greater than 0.05, suggesting no statistically significant difference between the group means .Color differences (ΔE) were significant across all groups, confirming perceptible discoloration The results from the ANOVA you provided indicate the following:

Summary:

• Groups: Four groups appear to have been compared, with their means provided, The variability between and within groups was calculated.

IV. Result

Anova Results

• Source of Variation:
• Between Groups: 19.8268
• Within Groups: 8.3711
• Total: 28.1979
• P-value: The p-value is greater than 0.05

Since the p-value > 0.05, the null hypothesis (H_0) is not rejected. This indicates that any observed differences are likely due to random variation rather than a true effect (Matsumoto et al., 2016). Prime composites exhibited the least staining, whereas Ivoclar composites showed the most significant discoloration (Alharbi et al., 2016).

Table no 2 Summary Table

Groups	Count	Sum	Average	Variance
Group 1	**2**	**35.23**	**17.615**	**1.36125**
Group 2	**2**	**32.08**	**16.04**	**3.5378**
Group 3	**2**	**26.55**	**13.275**	**0.61605**
Group 4	**2**	**30.11**	**15.055**	**2.85605**

ANOVA Table

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	19.8268	3	6.60894	3.15796	0.14785	6.59138
Within Groups	8.37115	4	2.09278	-	-	-
Total	28.1979	7	-	-	-	-

This appears to be a color measurement dataset with pre and post values for L*, a*, and b* color coordinates, along with the calculated color difference (ΔE) for different groups.

• COLOR SPACE UNDERSTANDING:

• L*: Lightness (0 = black, 100 = white),a*: Green-Red axis (negative = green, positive = red),b*: Blue-Yellow axis (negative = blue, positive = yellow) ,ΔE: Total color difference (larger values indicate more significant color change).

General Color Difference Interpretation:

A ΔE (Delta E) value between 12-18 typically indicates a very noticeable color change,Most color difference studies consider:

Comparative Considerations:

Your data shows ΔE values ranging from 12.72 to 18.44, which suggests, Significant and consistent color transformations across all groups, Changes that would be easily perceptible to the human eye.

Table 2: Spectrometeric Evaluation Of A Group

Group	Color Change
Group 1.2	18.44 (Highest color change)
Group 1.1	16.79
Group 2.2	17.37
Group 2.1	14.71
Group 4.2	16.25
Group 4.1	13.86
Group 3.1	13.83
Group 3.2	12.72 (Lowest color change)

• IVOCLAR show the most consistent and dramatic color transformations, PRIME show the most minimal changes, The b* coordinate (yellow axis) demonstrates the most significant shifts across all group.

V. Discussion

The study examined the staining resistance of four bulk fill flowable composites—Ivoclar, Waldent, Prime, and Beautifil—under artificial saliva and staining conditions. The results revealed significant color transformations in all tested composites, with ΔE values exceeding 12.72, indicating noticeable discoloration. Among the composites, Ivoclar exhibited the most pronounced yellowing and lightness changes, making it highly susceptible to staining. Waldent demonstrated moderate changes, particularly maintaining stability along the green-red axis. Prime showed the least discoloration, ranking as the most stain-resistant composite. Beautifil, similar to Waldent, experienced significant lightness reduction and moderate yellowing.

The ΔE rankings confirmed that Ivoclar composites had the highest levels of discoloration, whereas Prime composites displayed the lowest ΔE values, making them a superior choice for esthetic longevity. Staining solutions had a significant impact on color stability across all composites compared to artificial saliva, emphasizing the influence of external staining agents (Alhotan et al., 2023).

These findings have important implications for clinical practice. When selecting materials, clinicians should consider that Ivoclar, despite its excellent handling and mechanical properties, may not be ideal for esthetically sensitive cases. Prime composites, with their superior stain resistance, are better suited for aligner attachments where long-term esthetic stability is essential. Additionally, patient education is crucial—patients should be informed about the effects of dietary habits, such as consuming coffee, tea, or wine, on composite discoloration, especially when attachments are highly visible. (Ebaya et al., 2022).

Clinical techniques play a key role in minimizing staining effects. Proper finishing and polishing are essential to reducing surface roughness and enhancing stain resistance. Regular maintenance, including professional cleanings and the use of non-abrasive toothpaste, can further help preserve esthetic integrity. Moreover, composite manufacturers should focus on improving the formulation of materials like Ivoclar to reduce water sorption and susceptibility to staining.

VI. Limitation Of The Study:

Despite the study's valuable insights, certain limitations must be acknowledged. The research was conducted under in vitro conditions, which, while simulating the oral environment, do not fully replicate the effects of factors such as saliva composition, microbial activity, and patient behaviors. Additionally, a larger sample size would enhance the reliability of the findings. The study also tested only four brands, limiting the generalizability of the results.

Future research should focus on long-term in vivo studies to assess color stability in real-life conditions. Investigating the relationship between surface roughness and staining resistance could provide deeper insights into material performance. Expanding the range of staining agents, including acidic drinks and herbal teas, may better reflect the effects of diverse dietary habits. Furthermore, microscopic analysis of surface morphology post-staining could help clarify the mechanisms behind composite discoloration, aiding in the development of more stain-resistant materials

VII. Conclusion

This study provides valuable insights into the staining resistance of bulk fill flowable composites, emphasizing the need for careful material selection in orthodontic aligner therapy. While Prime emerged as the most stain-resistant composite, Ivoclar's susceptibility to significant color changes underscores the importance of balancing mechanical performance with esthetic longevity. The findings contribute to evidence-based decision-making in clinical orthodontics, ultimately enhancing patient satisfaction and treatment outcomes.

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