

# 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:** With an increasing demand for esthetic orthodontic solutions, clear aligner therapy has gained popularity due to its discreet appearance (Kwon et al., 2020). However, the use of flowable composite attachments with aligners can present challenges, particularly in maintaining color stability under various staining conditions (Almeida et al., 2017). This study investigates the staining resistance of four bulk-fill flowable composites commonly used for orthodontic attachments, assessing their susceptibility to discoloration from everyday staining agents (Aldhafyan et al., 2021). A preliminary pilot study was conducted to refine the methodology, ensuring accurate spectrophotometric assessment and optimizing sample preparation. The main study evaluates color stability across four brands—Prime Dental Bulk Fill, Ivoclar Bulk Fill, Beautiful Bulk Fill, and Waldent Bulk Fill (all in shade A2)—the study aims to identify materials that maintain visual appeal over time. Using a spectrophotometric assessment within the CIE Lab\* color space and statistical analysis via one-way ANOVA, the research provides insights into composite performance, guiding clinicians in selecting materials that meet esthetic standards in aligner therapy (Vichi et al., 2014). This study addresses an important gap in the literature regarding composite staining in orthodontics, supporting evidence-based material selection to enhance patient satisfaction and treatment outcomes (Lu et al., 2017).

**Keywords:** Clear aligner therapy, Esthetic orthodontics ,Color stability, Orthodontic attachments ,Spectrophotometric assessment.

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## I. BACKGROUND:

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 METHOD

This is an experimental laboratory study. The study population included four groups of flowable bulk-fill composites. The sample size was set at four for each composite Bulkfill-flowable composites (figure 1)



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

### PROCEDURE

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<sup>2</sup> 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 polymerisation process and proximity to oral conditions. Specimens of each type of composite were divided into eight groups.

Group 1:1 ivoclar composite with artificial saliva

Group 1:2 ivoclar composite with staining solution

Group 2:1 waldent composite with artificial saliva

Group 2:2 waldent composite with staining solution

Group 3:1 prime composite with artificial saliva

Group 3:2 prime composite with staining solutions

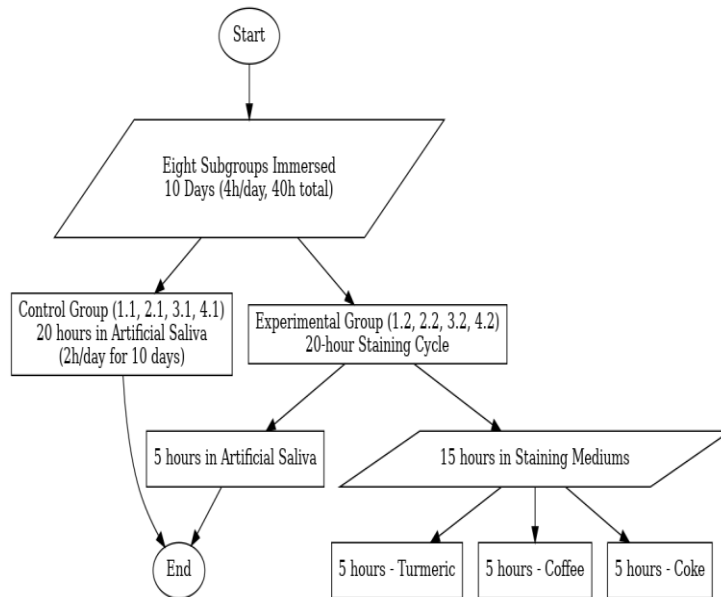
Group 4:1 beautifil composite with artificial saliva

Group 4:2 beautifil composite with staining solutions

The eight subgroups were immersed for 10 days , 4h a day ,40 hrs 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-tumeric 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.

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

FLOWCHART (figure2)



SPECTROPHOTOMETER (figure 3)



### III. RESULTS:

The results from the ANOVA indicate that the p-value is greater than 0.05, suggesting no statistically significant difference between the group means (Gupta et al., 2011). Color differences ( $\Delta E$ ) were significant across all groups, confirming perceptible discoloration (Paravina et al., 2004).

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.

#### 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 1**

$\Delta E$	INFERENCE
$\Delta E < 1.0$	Imperceptible to the human eye
$\Delta E 1-2$	Slight difference, barely noticeable
$\Delta E 2-3.5$	Noticeable difference
$\Delta E 3.5-5.0$	Clearly visible difference
$\Delta E > 5.0$	Significant color change

**STATISTICAL ANALYSIS (ANOVA SINGLE FACTOR)**

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
group 1	2	35.23	17.615	1.36125
group2	2	32.08	16.04	3.5378
group3	2	26.55	13.275	0.61605
group4	2	30.11	15.055	2.85605

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	19.8268	4	6.60894	3.15796	0.14785	6.59138
Within Groups	8.37115	4	2.09278	3	7	2
Total	28.1979	9	7			

ANOVA (TABLE 2)

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 ( $\Delta E$ ) for different groups.

Let's break down the key observations:

• 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)
- $\Delta E$ : Total color difference (larger values indicate more significant color change)

General Color Difference Interpretation:

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

Comparative Considerations:

- Your data shows  $\Delta E$  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 3**

Total Color Difference ( $\Delta E$ ) Ranking:

GROUPS	( $\Delta E$ ) VALUES
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

<b>Group 4.1</b>	13.86
<b>Group 3.1</b>	13.83
<b>Group 3.2</b>	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 groups
- There's a general trend towards decreased lightness and increased yellowness.

#### IV. 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  $\Delta E$  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  $\Delta E$  rankings confirmed that Ivoclar composites had the highest levels of discoloration, whereas Prime composites displayed the lowest  $\Delta E$  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.

#### 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.

#### V. 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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