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# A Comparative Study on Shear Bond Strength of Conventional and Highly Filled Flowable Composites in Bonding the Orthodontic Metal Brackets: An In-Vitro Study

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**Abstract:**

➢ ***Aim and Objectives:***

**The study aimed to evaluate and compare the shear bond strength of Wizdent Master Design - the Intelligent Adaptive Restorative, Shofu Beautifil Injectable-Fluoride releasing flowable restorative material, 3M™ Filtek™ Supreme flowable Restorative, Ormco Enlight Light Cure Adhesive, Ivoclar Tetric N-Flow for orthodontic metal bracket bonding with standard orthodontic adhesive-3M Unitek Transbond XT Light cure Adhesive Paste , and to compare the shear bond strength values among the six groups to determine relative performance.**

➢ ***Materials and Methods:***

**66 extracted human premolars were randomly assigned to six groups (n=11)**

- **Group I: Wizdent Master Design - the Intelligent Adaptive Restorative**
- **Group II: Shofu Beautifil Injectable-Fluoride releasing flowable material**
- **Group III: 3M™ Filtek™ Supreme flowable**
- **Group IV: Ormco Enlight Light Cure Adhesive**
- **Group V: Ivoclar Tetric N Flow**
- **Group VI: 3M Unitek Transbond XT Light cure Adhesive Paste (standard control adhesive)**

**The freshly extracted premolar teeth were embedded on acrylic blocks with the buccal surface exposed. The enamel surface of the extracted tooth was polished with pumice slurry for 5 seconds and then rinsed with distilled water. This was then air-dried. The enamel was etched with 37% phosphoric acid for 30 seconds and rinsed for 10 seconds and then air-dried for 30 seconds. Bonding agent was then applied and the brackets were bonded using respective adhesives and then cured for 20 seconds. Shear bond strength was tested in Universal testing machine and results were analyzed using one way Anova with Tukeys Posthoc Analysis[$p<0.05$].**

➢ ***Results:***

**Tukeys Posthoc analysis revealed that the significant differences observed in ANOVA were mainly attributed to the higher performance of Ormco Enlight and 3M Filtek Supreme Flowable, while Wizdent Master Design, Shofu Beautifil Injectable demonstrated comparatively lower values. Transbond XT (3M Unitek) and Ivoclar Tetric N-Flow showed moderate performance, with minimal statistically significant differences between them. These results highlight the influence of material choice on both maximum load and shear bond strength.**

➢ ***Conclusion:***

**Ormco Enlight Light Cure Adhesive and 3M Filtek Supreme Flowable demonstrated significantly higher shear bond strength and maximum load values, while Shofu Beautifil Injectable showed comparatively lower performance. Transbond XT and Ivoclar Tetric N-Flow exhibited intermediate bond strength within clinically acceptable limits. These findings indicate that material selection plays a crucial role in optimizing orthodontic bracket bonding, with orthodontic-specific adhesives and certain flowable composites providing superior bonding performance.**

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***Keywords:*** *Shear Bond Strength,Orthodontic Brackets,Wizdent Master Design,Ormco Enlight.*

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## I. INTRODUCTION

The introduction of newer adhesive material systems, including flowable composite materials, has further increased variability regarding their suitability for orthodontic bracket bonding, as the findings suggest variations in performance when compared with conventional adhesive materials.[3]

Despite the availability of previous research evidences, there remains a need for systematic comparison of orthodontic adhesives under standardized conditions to give evidence that helps clinicians in making good material choices. Such kind of evaluation is necessary to improve treatment efficiency, reduce bracket failures, and minimize enamel damage during debonding the orthodontic brackets, thereby improving overall clinical outcomes in orthodontic practice.[1,3]

The Wizdent Master Design - the Intelligent Adaptive Restorative adhesive system is one such innovation that is developed to provide high bond strength with easy handling. However, in-vitro study on the effectiveness in orthodontic bracket bonding are less. Setting up its bond strength relative to conventional composites and flowable composites is critical to determine whether it can be used as a reliable alternative in routine clinical practice.

## II. MATERIAL & METHODS

➢ *Study Design*

This was an in vitro experimental study conducted in the Department of Orthodontics and Dentofacial Orthopaedics, KVG Dental College and Hospital, Sullia. The study was completed over 3 months. Shear bond strength testing was performed using a Universal Testing Machine provided by the Praj Dental Laboratory, Pune, Maharashtra ensuring precise and standardized measurement of debonding forces.

➢ *Sample Selection*

A total of 66 extracted human first premolars indicated for orthodontic purposes were acquired. Teeth were cleaned and preserved in distilled water until use.

➢ *Inclusion Criteria*

- Extracted human first premolars.
- Intact buccal enamel surface.
- Teeth free from caries, developmental defects, or discolorations.
- Teeth without cracks or fractures.

➢ *Exclusion Criteria*

- Teeth with caries.
- Teeth with restorations.
- Teeth with visible cracks or fractures.
- Teeth previously bonded with brackets.
- Teeth that had undergone any chemical treatment.

➢ *Materials Used*

- Self-cure acrylic resin – DPI-RR.
- Wizdent Master Design - the Intelligent Adaptive Restorative
- Shofu Beautifil Injectable-Fluoride releasing flowable restorative material
- 3M™ Filtek™ Supreme flowable Restorative
- Ormco Enlight Light Cure Adhesive
- Ivoclar Tetric N-Flow
- 3M Unitek Transbond XT Light cure Adhesive Paste
- Bonding Agent-Single bond universal
- Orthodontic brackets: Pre-adjusted Edgewise stainless steel brackets, MBT prescription- 0.022x0.028” slot
- Light curing unit: Standard LED curing light
- Applicator brushes
- Universal Testing Machine (UTM): For shear bond strength testing.

## III. METHODOLOGY

➢ *Tooth Preparation*

The freshly extracted first premolar tooth were embedded on acrylic blocks with the buccal surface exposed. The enamel surface of the extracted tooth was polished with pumice slurry for 5 seconds and then rinsed with distilled water. This was then air-dried.

➢ *Bonding Procedure*

- *Etching Protocol:*

Enamel was etched with 37% phosphoric acid for 30 seconds and rinsed for 10 seconds and then it was air-dried for 30 seconds.

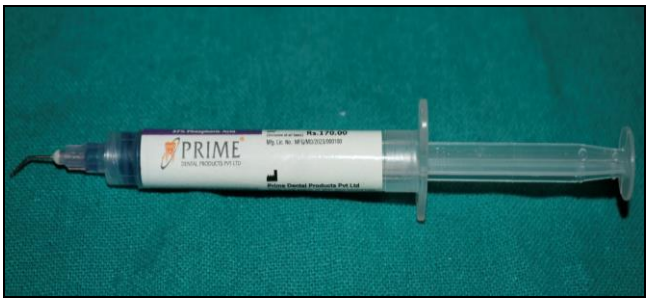


Fig 1 Etchant Gel used in the Study [Prime Dental Etching Liquid]

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Fig 2 Application of Etchant-37%Phosphoric Acid


Fig 3 Bonding Agent- Single Bond Universal

- *Group I (3M Unitek Transbond XT Light Cure Adhesive Paste):*

Primer was applied after etching the enamel surface and the brackets were bonded using 3M Unitek Transbond XT Light cure Adhesive Paste.


Fig 4 3M™ *Transbond™ XT* Light Cure *Adhesive*.

- *Group II (Wizdent Master Design - the Intelligent Adaptive Restorative):*

Brackets were bonded after etching the tooth surface with 37%Phosphoric acid. Then it was air dried, bonding agent was applied and cured for 20 seconds.


Fig 5 Wizdent Master Design - the Intelligent Adaptive Restorative

- *Group III (Shofu Beautifil Injectable-Fluoride Releasing Flowable Restorative Material):*

Brackets were bonded after etching and bonding the enamel surface.


Fig 6 Shofu Beautifil Injectable-Fluoride Releasing Flowable Restorative Material

- *Group IV (3M™ Filtek™ Supreme Flowable Restorative):*

Brackets was bonded after etching and bonding the enamel surface.


Fig 7 3M™ Filtek™ Supreme Flowable Restorative

- *Group V (Ivoclar Tetric N-Flow):*

Brackets was bonded after etching and bonding the enamel surface.

Fig 8 Ivoclar Tetric N-Flow

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- *Group VI (Ormco Enlight Light Cure Adhesive):*

Brackets were bonded after etching the tooth surface with 37%Phosphoric acid. Then it was air dried, bonding agent was applied and cured for 20 seconds.

Fig 9 Ormco Enlight Light Cure Adhesive.

✓ *Curing:*

Orthodontic metal brackets were cured for 20 seconds.

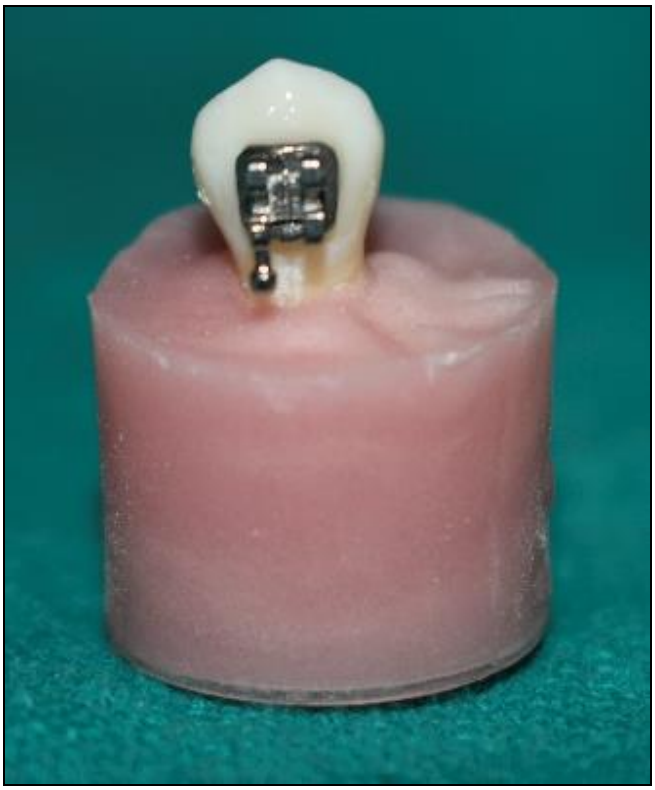

Fig 10 Bonding of the Pre-Adjusted Edgewise Stainless Steel Bracket, MBT Prescription- 0.022x0.028" Slot

➢ *Shear Bond Strength Testing*

Shear bond strength was tested in Universal testing machine at a crosshead speed of 0.5 mm/min.
Force at debonding was documented in Newton and converted to MPa (SBS = Force / Bracket base area).


Fig 11 Universal Testing Machine for Shear Bond Strength Testing

Fig 12 Shear Bond Strength Testing at a Crosshead Speed of 0.5 mm/min.

➢ *Statistical Analysis*

- SPSS version 28 software was used for the analysis.
- Descriptive statistics like mean and standard deviation was calculated for continuous variables.
- Frequency and percentage was measured for categorical variables.
- One way Anova with Tukeys Posthoc Analysis was used to measure the mean difference.
- Statistical significance set at P <0.05.

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## IV. RESULTS

➢ *Shear Bond Strength of 6 Different Adhesive Materials-*

- Ormco Enlight Light Cure Adhesive -9.42MPa
- 3M™ Filtek™ Supreme flowable Restorative -9.04MPa
- 3M™ *Transbond™ XT* Light Cure *Adhesive* -6.05MPa
- Ivoclar Tetric N-Flow-4.96MPa
- Wizdent Master Design - the Intelligent Adaptive Restorative -3.76Mpa
- Shofu Beautifil Injectable-Fluoride releasing flowable restorative material -2.31MPa

Table 1 Comparison of Max. Load and Shear Bond Strength between Different Materials

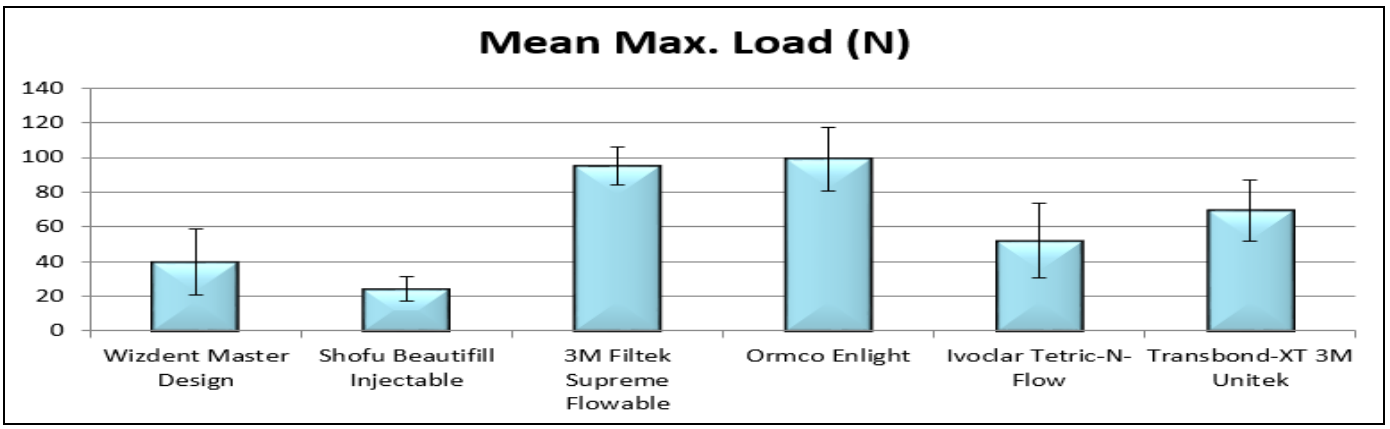
| | | N | Mean | SD | F | P Value |
|---|---|---|---|---|---|---|
| Max. Load (N) | Wizdent Master Design | 11 | 39.5818 | 19.01725 | 36.859 | 0.001* |
| | Shofu Beautifill Injectable | 11 | 24.3182 | 7.32555 | | |
| | 3M Filtek Supreme Flowable | 11 | 95.0455 | 10.7853 | | |
| | Ormco Enlight | 11 | 99 | 18.28114 | | |
| | Ivoclar Tetric-N-Flow | 11 | 52 | 21.36937 | | |
| | Transbond-XT 3M Unitek | 11 | 69.4091 | 17.30869 | | |
| Shear Bond Strength (MPa) | Wizdent Master Design | 11 | 3.7664 | 1.81033 | 36.878 | 0.001* |
| | Shofu Beautifill Injectable | 11 | 2.3109 | 0.69848 | | |
| | 3M Filtek Supreme Flowable | 11 | 9.0482 | 1.02604 | | |
| | Ormco Enlight | 11 | 9.4227 | 1.74062 | | |
| | Ivoclar Tetric-N-Flow | 11 | 4.9464 | 2.03476 | | |
| | Transbond-XT 3M Unitek | 11 | 6.6064 | 1.64817 | | |

The one-way analysis of variance (ANOVA) was conducted to compare the mean maximum load (N) and shear bond strength (MPa) among six different composite materials: Wizdent Master Design, Shofu Beautifill Injectable, 3M Filtek Supreme Flowable, Ormco Enlight, Ivoclar Tetric-N-Flow, and Transbond-XT 3M Unitek.

For maximum load (N)**,** the ANOVA revealed a statistically significant difference among the groups, $F(5, 60) = 36.86$, $p < .001$. Among the tested materials, Ormco Enlight demonstrated the highest mean maximum load (M = 99.00, SD = 18.28), closely followed by 3M Filtek Supreme Flowable (M = 95.05, SD = 10.79). Transbond-XT 3M Unitek showed a moderate mean value (M = 69.41, SD = 17.31), while Ivoclar Tetric-N-Flow (M = 52.00, SD = 21.37) and Wizdent Master Design (M = 39.58, SD = 19.02) exhibited comparatively lower values. Shofu Beautifill Injectable demonstrated the lowest maximum load (M = 24.32, SD = 7.33). The statistically significant F value indicates that at least one material differs significantly from the others in terms of maximum load-bearing capacity.

Similarly, for shear bond strength (MPa), the ANOVA showed a statistically significant difference among the materials, $F(5, 60) = 36.88$, $p < .001$. Ormco Enlight exhibited the highest mean shear bond strength (M = 9.42, SD = 1.74), followed closely by 3M Filtek Supreme Flowable (M = 9.05, SD = 1.03). Transbond-XT 3M Unitek demonstrated moderate bond strength (M = 6.61, SD = 1.65), while Ivoclar Tetric-N-Flow (M = 4.95, SD = 2.03) and Wizdent Master Design (M = 3.77, SD = 1.81) showed lower values. Shofu Beautifill Injectable again exhibited the lowest shear bond strength (M = 2.31, SD = 0.70). The significant ANOVA result confirms that the differences observed in shear bond strength among the materials are not due to chance.

Overall, the findings indicate that both maximum load and shear bond strength vary significantly across the tested materials. Notably, Ormco Enlight and 3M Filtek Supreme Flowable consistently demonstrated superior mechanical properties, whereas Shofu Beautifill Injectable showed the least performance in both parameters. These results suggest that material selection plays a critical role in influencing both load-bearing capacity and bond strength in clinical applications.



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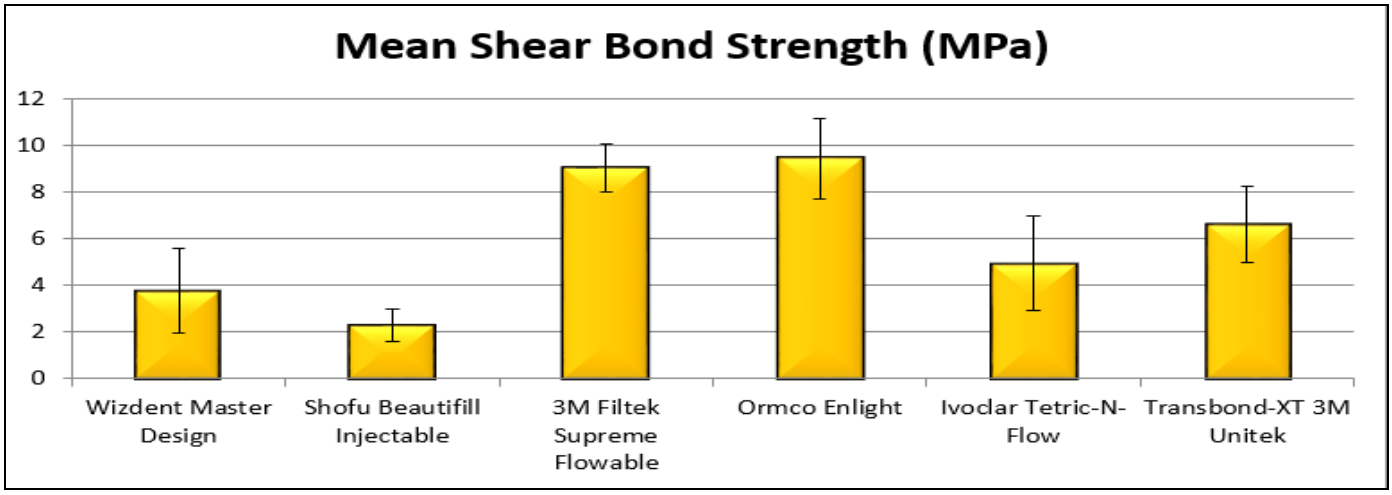


Fig 13 Comparison of Max. Load and Shear Bond Strength between Different materials using Tukey's Posthoc Analysis

Table 2 Multiple Comparison of Max. Load and Shear Bond Strength between Different materials using Tukey's Posthoc Analysis

| Dependent variable | (I) Groups | (J) Groups | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Max. Load(N) | Wizdent Master Design | Shofu Beautifill Injectable | 15.26 | 7.01 | 0.264 | -5.38 | 35.90 |
| | | 3M Filtek Supreme Flowable | -55.46 | 7.01 | 0.001* | -76.10 | -34.82 |
| | | Ormco Enlight | -59.42 | 7.01 | 0.001* | -80.06 | -38.78 |
| | | Ivoclar Tetric-N-Flow | -12.42 | 7.01 | 0.492 | -33.06 | 8.22 |
| | | Transbond-XT 3M Unitek | -29.83 | 7.01 | 0.001* | -50.47 | -9.19 |
| | Shofu Beautifill Injectable | 3M Filtek Supreme Flowable | -70.73 | 7.01 | 0.001* | -91.37 | -50.09 |
| | | Ormco Enlight | -74.68 | 7.01 | 0.001* | -95.32 | -54.04 |
| | | Ivoclar Tetric-N-Flow | -27.68 | 7.01 | 0.003* | -48.32 | -7.04 |
| | | Transbond-XT 3M Unitek | -45.09 | 7.01 | 0.001* | -65.73 | -24.45 |
| | 3M Filtek Supreme Flowable | Ormco Enlight | -3.95 | 7.01 | 0.993 | -24.59 | 16.68 |
| | | Ivoclar Tetric-N-Flow | 43.05 | 7.01 | 0.001* | 22.41 | 63.68 |
| | | Transbond-XT 3M Unitek | 25.64 | 7.01 | 0.007* | 5.00 | 46.28 |
| | Ormco Enlight | Ivoclar Tetric-N-Flow | 47.00 | 7.01 | 0.001* | 26.36 | 67.64 |
| | | Transbond-XT 3M Unitek | 29.59 | 7.01 | 0.001* | 8.95 | 50.23 |
| | Ivoclar Tetric-N-Flow | Transbond-XT 3M Unitek | -17.41 | 7.01 | 0.146 | -38.05 | 3.23 |
| Shear Bond Strength (MPa) | Wizdent Master Design | Shofu Beautifill Injectable | 1.46 | 0.67 | 0.262 | -0.51 | 3.42 |
| | | 3M Filtek Supreme Flowable | -5.28 | 0.67 | 0.001* | -7.25 | -3.32 |
| | | Ormco Enlight | -5.66 | 0.67 | 0.001* | -7.62 | -3.69 |
| | | Ivoclar Tetric-N-Flow | -1.18 | 0.67 | 0.494 | -3.15 | 0.79 |
| | | Transbond-XT 3M Unitek | -2.84 | 0.67 | 0.001* | -4.81 | -0.87 |
| | Shofu Beautifill Injectable | 3M Filtek Supreme Flowable | -6.74 | 0.67 | 0.001* | -8.70 | -4.77 |
| | | Ormco Enlight | -7.11 | 0.67 | 0.001* | -9.08 | -5.15 |
| | | Ivoclar Tetric-N-Flow | -2.64 | 0.67 | 0.003* | -4.60 | -0.67 |
| | | Transbond-XT 3M Unitek | -4.30 | 0.67 | 0.001* | -6.26 | -2.33 |
| | 3M Filtek Supreme Flawable | Ormco Enlight | -0.37 | 0.67 | 0.993 | -2.34 | 1.59 |
| | | Ivoclar Tetric-N-Flow | 4.10 | 0.67 | 0.001* | 2.14 | 6.07 |
| | | Transbond-XT 3M Unitek | 2.44 | 0.67 | 0.007* | 0.48 | 4.41 |
| | Ormco Enlight | Ivoclar Tetric-N-Flow | 4.48 | 0.67 | 0.001* | 2.51 | 6.44 |
| | | Transbond-XT 3M Unitek | 2.82 | 0.67 | 0.001* | 0.85 | 4.78 |
| | Ivoclar Tetric-N-Flow | Transbond-XT 3M Unitek | -1.66 | 0.67 | 0.144 | -3.63 | 0.31 |

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Posthoc pairwise comparisons using Tukey's Honestly Significant Difference (HSD) test were performed to further explore the differences in maximum load (N) and shear bond strength (MPa) among the six composite materials.

- *Maximum Load (N)*-

The Tukey HSD analysis revealed several statistically significant pairwise differences. Wizdent Master Design demonstrated significantly lower maximum load compared to 3M Filtek Supreme Flowable (MD = −55.46, $p < .001$, 95% CI [−76.10, −34.82]), Ormco Enlight (MD = −59.42, $p < .001$, 95% CI [−80.06, −38.78]), and Transbond-XT 3M Unitek (MD = −29.83, $p < .001$, 95% CI [−50.47, −9.19]). However, no significant differences were observed between Wizdent Master Design and Shofu Beautifill Injectable ($p = .264$) or Ivoclar Tetric-N-Flow ($p = .492$).

Shofu Beautifill Injectable exhibited significantly lower maximum load compared to all other materials, including 3M Filtek Supreme Flowable (MD = −70.73, $p < .001$), Ormco Enlight (MD = −74.68, $p < .001$), Ivoclar Tetric-N-Flow (MD = −27.68, $p = .003$), and Transbond-XT 3M Unitek (MD = −45.09, $p < .001$), confirming its inferior performance.

No statistically significant difference was found between 3M Filtek Supreme Flowable and Ormco Enlight ($p = .993$), indicating comparable maximum load values between these two high-performing materials. However, both materials showed significantly higher maximum load than Ivoclar Tetric-N-Flow (MD = 43.05, $p < .001$; MD = 47.00, $p < .001$, respectively) and Transbond-XT 3M Unitek (MD = 25.64, $p = .007$; MD = 29.59, $p < .001$, respectively).

Additionally, Ivoclar Tetric-N-Flow and Transbond-XT 3M Unitek did not differ significantly from each other ($p = .146$), suggesting comparable intermediate performance.

Overall, the results indicate that Ormco Enlight and 3M Filtek Supreme Flowable exhibited the highest and statistically similar maximum load values, while Shofu Beautifill Injectable showed significantly lower performance compared to all other groups.

- *Shear Bond Strength (Mpa)*-

For shear bond strength, Tukey HSD analysis similarly demonstrated multiple significant differences. Wizdent Master Design showed significantly lower bond strength compared to 3M Filtek Supreme Flowable (MD = −5.28, $p < .001$, 95% CI [−7.25, −3.32]), Ormco Enlight (MD = −5.66, $p < .001$, 95% CI [−7.62, −3.69]), and Transbond-XT 3M Unitek (MD = −2.84, $p < .001$, 95% CI [−4.81, −0.87]). However, differences between Wizdent Master Design and Shofu Beautifill Injectable ($p = .262$) and Ivoclar Tetric-N-Flow ($p = .494$) were not statistically significant.

Shofu Beautifill Injectable again demonstrated significantly lower shear bond strength than all other materials, including 3M Filtek Supreme Flowable (MD = −6.74, $p < .001$), Ormco Enlight (MD = −7.11, $p < .001$), Ivoclar Tetric-N-Flow (MD = −2.64, $p = .003$), and Transbond-XT 3M Unitek (MD = −4.30, $p < .001$).

No statistically significant difference was observed between 3M Filtek Supreme Flowable and Ormco Enlight ($p = .993$), indicating comparable and superior bond strength values. Both materials demonstrated significantly higher shear bond strength than Ivoclar Tetric-N-Flow (MD = 4.10, $p < .001$; MD = 4.48, $p < .001$, respectively) and Transbond-XT 3M Unitek (MD = 2.44, $p = .007$; MD = 2.82, $p < .001$, respectively).

Finally, the difference between Ivoclar Tetric-N-Flow and Transbond-XT 3M Unitek was not statistically significant ($p = .144$), indicating similar moderate performance between these two materials.

- *Overall Interpretation*-

The Tukey HSD post hoc analysis confirms that the statistically significant differences identified in the ANOVA are primarily driven by the superior performance of Ormco Enlight and 3M Filtek Supreme Flowable, and the inferior performance of Shofu Beautifill Injectable. Materials such as Transbond-XT 3M Unitek and Ivoclar Tetric-N-Flow demonstrated intermediate values with fewer significant differences between them. These findings reinforce the importance of material selection in optimizing both maximum load and shear bond strength in clinical applications.

## V. DISCUSSION

The present in-vitro study demonstrated clear differences in shear bond strength among the tested materials, highlighting the critical role of adhesive material selection in orthodontic bracket bonding. The Tukey posthoc analysis showed that Ormco Enlight and 3M Filtek Supreme Flowable exhibited significantly higher bond strength values, whereas Shofu Beautifil Injectable and Wizdent Master Design showed comparatively lower performance. Transbond XT (3M Unitek) and Ivoclar Tetric N-Flow displayed intermediate bond strengths, with minimal statistically significant differences between them.

The superior performance of Ormco Enlight and 3M Filtek Supreme Flowable may be attributed to their improved filler loading and resin matrix composition, which increases the mechanical properties and improve adhesion to enamel surfaces. Highly filled flowable composite materials are known to offer a balance between adequate viscosity and improved wettability, allowing better penetration into the etched enamel micro-porosities, thereby promoting micromechanical retention. These findings are consistent with the earlier studies, such as those by Bishara et al. in 2001 and Uysal et al. in 2004, which reported that materials with increased filler content and improved handling characteristics tend to exhibit higher bond strength values suitable for orthodontic applications.[12,3]

In contrast, the lower bond strength observed with Beautifill Injectable may be related to its giomer-based composition, which incorporates pre-reacted glass ionomer fillers. While such materials offer cariostatic benefits through fluoride release, this modification may compromise their mechanical strength and adhesive capability. This also

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supports the findings of Cacciafesta et al. in 2005 and other researchers who have noted that materials designed for fluoride release may exhibit reduced bond strength compared to conventional orthodontic adhesives.[13]

The intermediate performance of Transbond XT and Ivoclar Tetric N-Flow aligns with their well-documented clinical reliability. Transbond XT, in particular, has long been considered a gold standard in orthodontic bonding due to its consistent bond strength and predictable clinical outcomes, as highlighted by Reynolds in 1975, who suggested that a minimum bond strength of 6–8 MPa is adequate for routine orthodontic treatment. The comparable performance of Tetric N-Flow suggests that certain flowable composites can achieve clinically acceptable bond strength, supporting their potential use as alternatives to conventional adhesives.

Overall, the findings of this study reinforce the importance of selecting bonding materials based not only on their mechanical strength but also on their compositional properties and clinical performance. While newer materials with bioactive or fluoride-releasing capabilities offer additional preventive benefits, clinicians must carefully evaluate the potential trade-offs in bond strength. Future research, particularly long-term in vivo studies, is recommended to further validate these results and assess their clinical applicability under oral conditions.

## VI. CONCLUSION

Within the limitations of this in vitro study, it can be concluded that the choice of bonding material significantly influences the shear bond strength and maximum load of orthodontic brackets. Ormco Enlight Light Cure Adhesive and 3M Filtek Supreme Flowable demonstrated superior performance, indicating their ability to provide strong and reliable bonding under the tested conditions. In contrast, Shofu Beautifil Injectable exhibited comparatively lower bond strength values, suggesting that its use may require careful clinical consideration, particularly in situations demanding higher mechanical stability.

Transbond XT (3M Unitek) and Ivoclar Tetric N-Flow showed intermediate performance, with bond strengths falling within clinically acceptable ranges and fewer statistically significant differences between them. This suggests that both materials remain suitable for routine orthodontic bonding, offering a balance between performance and reliability.

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