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Comparative Evaluation of Fracture Resistance of Premolar Teeth Restored with Monochromatic Composites and Nanocomposite in Class II Cavities – An *in -vitro* Study

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Abstract

Background: The longevity and clinical success of posterior composite restorations depend largely on their mechanical properties, particularly fracture resistance. With advancements in restorative dentistry, newer monochromatic composites have been introduced to simplify shade matching while maintaining acceptable strength and esthetics. However, limited evidence exists comparing their fracture resistance with conventional nanocomposites in Class II restorations.

Aim: To evaluate and compare the fracture resistance of premolar teeth restored with two monochromatic composites and one nanocomposite in standardized Class II cavities.

Materials and Methods: Forty extracted human premolar teeth were disinfected and mounted in acrylic resin blocks 2 mm apical to the cementoenamel junction. Standardized Class II cavities were prepared with an occlusal depth of 2 mm and proximal box depth of 1.5 mm. The specimens were randomly divided into four groups (n = 10):

- Group I – Intact teeth (control)
- Group II – Restored with Omnichroma
- Group III – Restored with Vittra Unique APS
- Group IV – Restored with Filtek Z350

All cavity surfaces were etched using 37% phosphoric acid for 15 seconds, followed by application of a universal bonding agent and light curing for 20 seconds. Restorations were completed using the incremental layering technique. The specimens were subjected to thermocycling for 10,000 cycles between 5°C and 55°C to simulate oral conditions. Fracture resistance was evaluated using a universal testing machine with a 3 mm steel ball applied perpendicular to the restoration at a crosshead speed of 0.5 mm/min until fracture occurred. The obtained values were statistically analyzed using one-way ANOVA and post hoc Tukey test with significance set at $p < 0.05$.

Results: Among the restored groups, Omnichroma demonstrated the highest fracture resistance values, followed by Vittra Unique APS, whereas Filtek Z350 exhibited the lowest fracture resistance. Intact teeth showed significantly greater resistance compared to all restored groups. Statistical analysis revealed significant differences among the experimental groups ($p < 0.05$).

Conclusion: Monochromatic composites demonstrated superior fracture resistance compared to the conventional nanocomposite tested in this study. Omnichroma showed the best performance, which may be attributed to its advanced filler technology and higher filler loading. The findings suggest that newer single-shade composites may provide enhanced mechanical durability and could be considered reliable restorative materials for posterior Class II restorations.

Introduction:

The long-term success of restorative procedures in posterior teeth depends on adequate mechanical strength, marginal integrity, and resistance to occlusal forces.[1] Class II restorations in premolar teeth are particularly susceptible to fracture because of extensive loss of tooth structure and continuous masticatory stresses.[2] Resin composites have become the material of choice for posterior restorations owing to their esthetic properties and adhesive bonding capability. However, polymerization shrinkage, wear, and inadequate fracture resistance may compromise their clinical longevity.[3]

Recent advances in restorative materials have led to the development of monochromatic or single-shade composites, which are designed to simplify shade selection while maintaining favorable optical and mechanical properties.[4] These materials utilize structural color technology and advanced filler systems to achieve improved esthetics and strength. Omnichroma and Vittra Unique APS are among the newer monochromatic composites introduced for universal shade matching in restorative dentistry.[5]

Nanocomposites such as Filtek Z350 have been widely used because of their improved polishability, filler distribution, and acceptable mechanical behavior. Nevertheless, variations in filler size, filler loading, and resin matrix composition among different composites may influence fracture resistance and overall restorative performance.[6]

Fracture resistance testing is commonly used to assess the ability of restorative materials to withstand occlusal forces and preserve tooth integrity. Therefore, evaluating the fracture resistance of newer monochromatic composites in comparison with conventional nanocomposites is important for determining their clinical applicability in stress-bearing posterior restorations.[7,8]

Hence, the present study was designed to evaluate and compare the fracture resistance of premolar teeth restored with Omnichroma, Vittra Unique APS, and Filtek Z350 in standardized Class II cavities. The null hypothesis stated that there would be no statistically significant difference in fracture resistance among the tested restorative materials.

Materials and Methodology: This in vitro experimental study was conducted at the Department of Conservative Dentistry and Endodontics, S. Nijalingappa Institute of dental sciences and research, Gulbarga, Karnataka, India, Institutional ethical clearance was obtained prior to commencement of the study.

Sample size estimation: Sample size was calculated using pwr package of R programming language and Data presentation, Descriptive statistics and comparison between groups by One way ANOVA and Post HOC test at 5% ($p<0.05$) level of significance.

Inclusion and exclusion criteria: Forty freshly extracted human premolar teeth extracted for orthodontic purposes were selected for the study. The teeth were cleaned of debris and soft tissue deposits using ultrasonic scalers and stored in distilled water until use.

The specimens were mounted in acrylic resin blocks 2 mm apical to the cementoenamel junction to simulate clinical support conditions. Standardized Class II cavities were prepared on all teeth except the intact control group using a high-speed handpiece with water coolant. The cavity dimensions included an occlusal depth of 2 mm and a proximal box depth of 1.5 mm, with buccolingual width approximately one-third of the intercuspal distance. The gingival floor was positioned 1 mm coronal to the cementoenamel junction. Cavity dimensions were verified using a periodontal probe to ensure standardization.[2,8]

The prepared teeth were randomly divided into four groups (n = 10):

- **Group I:** Intact unprepared teeth (control)
- **Group II:** Teeth restored with Omnichroma composite (Tokuyama Dental, Japan)
- **Group III:** Teeth restored with Vittra Unique APS composite (FGM Dental Group, Brazil)
- **Group IV:** Teeth restored with Filtek Z350 nanocomposite (3M Oral Care, USA)

Prior to restoration, all specimens were disinfected with 0.5% sodium hypochlorite for 15 minutes and stored in distilled water. The cavity surfaces were etched using 37% phosphoric acid for 15 seconds, thoroughly rinsed with water, and gently air dried. A universal bonding agent was applied to the cavity walls using a micro-applicator and light cured for 20 seconds according to the manufacturer's instructions.[9]

Restoration of the cavities was performed using the conventional incremental layering technique. A sectional matrix band system was used to restore the proximal contour of the Class II cavities. Each increment was light cured adequately to ensure complete polymerization.[10]

To simulate intraoral thermal stresses, all restored specimens were subjected to thermocycling using a thermocycler for 10,000 cycles between 5°C and 55°C with a dwell time of 15 seconds in each bath and transfer time of 5 seconds in accordance with ISO recommendations.[11]

Evaluation of Fracture Resistance: Fracture resistance testing was performed using a universal testing machine. The specimens were positioned so that the load was applied perpendicular to the restoration and centered over the proximal box region. A stainless-steel ball with a diameter of 3 mm was used to deliver compressive force at a crosshead speed of 0.5 mm/min until fracture occurred.

The maximum force required to fracture each specimen was recorded in Newtons (N). The obtained values were tabulated and subjected to statistical analysis.[12]

Statistical Analysis: The collected data were analyzed using SPSS software (version 25.0; IBM Corp., Armonk, NY, USA). Normality of distribution was assessed using the Shapiro–Wilk test. Intergroup comparisons of fracture resistance were performed using one-way analysis of variance (ANOVA). Post hoc Tukey's test was applied for pairwise comparison among groups. The level of statistical significance was set at $p < 0.05$.

Results: Table 1 and Table 2 demonstrated statistically significant differences in fracture resistance among all the experimental groups ($p < 0.0001$). The intact teeth group exhibited the highest mean fracture resistance value (1930 ± 34.96 N), indicating the superior strength of sound tooth structure when compared with restored specimens. Among the restored groups, Omnichroma exhibited the highest mean fracture resistance values, followed by Vittra Unique APS, whereas Filtek Z350 demonstrated the lowest fracture resistance values.

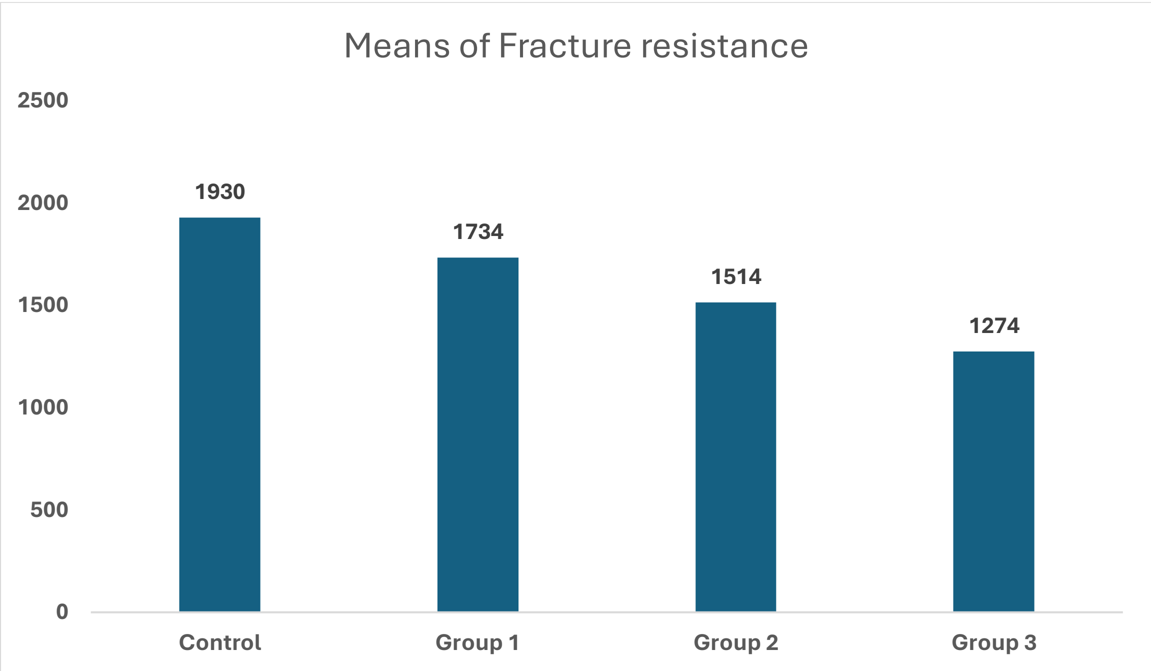
Statistical analysis revealed significant differences among the experimental groups ($p < 0.05$). The superior fracture resistance of Omnichroma may be attributed to its higher filler loading and advanced supra-nano spherical filler technology, which enhances stress distribution within the composite structure.[5]

Vittra Unique APS showed comparatively lower fracture resistance than Omnichroma but performed better than Filtek Z350. The improved performance of Vittra Unique APS may be related to its optimized filler system and advanced polymerization technology.[13]

Filtek Z350 exhibited the lowest fracture resistance among the restored groups, which may be associated with differences in filler loading and filler particle distribution compared with the monochromatic composites.[14]

Table 1: Means and SD (Standard deviation) of Fracture resistance and p value by ANOVA		
Groups	**Mean**	**SD**
Control	1930	34.96
Group 1	1734	32.04
Group 2	1514	60.77
Group 3	1274	54.20
P value	<0.0001(S)	

Table 2: Comparison of Fracture resistance between two groups by Post HOC Turkey test		
Comparison between	Difference	P value
Control and Group 1	196	<0.0001(S)
Control and Group 2	416	<0.0001(S)
Control and Group 3	656	<0.0001(S)
Group 1 and Group 2	220	<0.0001(S)
Group 1 and Group 3	460	<0.0001(S)
Group 2 and Group 3	240	<0.0001(S)



Discussion: The fracture resistance is an important factor influencing the longevity and clinical success of posterior composite restorations.[15] Premolar teeth restored with Class II restorations are subjected to considerable occlusal stresses because of the loss of marginal ridge integrity and reduced tooth stiffness. Therefore, restorative materials with superior mechanical properties are essential to reinforce weakened tooth structure.[2,7]

In the present study, Omnichroma demonstrated the highest fracture resistance among the restored groups. This finding may be attributed to its supra-nano spherical filler technology and high filler loading, which improve compressive and flexural strength. The structural color technology of Omnichroma not only provides esthetic advantages but may also contribute to better stress distribution within the restorative material.[5,16]

Vittra Unique APS exhibited fracture resistance values slightly lower than Omnichroma. The material contains advanced polymerization system technology and fine filler particles that improve esthetics and mechanical behavior. However, differences in filler composition and filler distribution may explain its comparatively lower performance.[14,17]

Filtek Z350 showed the lowest fracture resistance values among the restorative groups. Although nanocomposites possess favorable polishability and handling characteristics, lower filler loading and variations in particle distribution may reduce their ability to withstand compressive forces under occlusal loading.[6,14]

Thermocycling was performed in the present study to simulate oral environmental conditions. Repeated thermal changes may induce stresses at the tooth-restoration interface and influence the mechanical behavior of restorative materials. Despite thermocycling, monochromatic composites maintained superior fracture resistance, indicating their potential durability in clinical conditions.[11,18]

The results of the present study are consistent with previous investigations reporting improved mechanical performance of newer single-shade composite systems due to enhanced filler technology and resin matrix optimization.

Limitations: The present study was conducted under in vitro conditions and therefore may not completely simulate the complex oral environment. Factors such as cyclic masticatory loading, saliva, occlusal variations, and periodontal ligament simulation were not fully reproduced. In addition, only one type of cavity design and limited restorative materials were evaluated. Further long-term clinical studies are recommended to validate the findings.

Conclusion: Within the limitations of the present study, monochromatic composites demonstrated superior fracture resistance compared to the conventional nanocomposite evaluated. Omnichroma exhibited the highest fracture resistance among the restorative groups, followed by Vittra Unique APS, whereas Filtek Z350 demonstrated the lowest values.

The enhanced performance of monochromatic composites may be attributed to their advanced filler technology and improved mechanical properties. These materials may therefore serve as reliable alternatives for posterior Class II restorations requiring both esthetic and mechanical durability.

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