

Assessment of Flexural Strength of Zirconium Dioxide Fixed Partial Denture using three different Connector Designs: An *in vitro* Study

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Abstract

Background: Fixed partial dentures (FPDs) fabricated from zirconium dioxide (ZrO₂) have gained popularity due to their esthetic appeal and mechanical properties. Connector design plays a crucial role in the flexural strength of such prostheses. **Materials and Methods:** In this *in vitro* study, three different connector designs – conventional, modified, and adhesive – were assessed for their impact on the flexural strength of ZrO₂ FPDs. Thirty samples were fabricated for each connector design using standardized protocols. Flexural strength was evaluated using a universal testing machine, and the results were statistically analyzed. **Results:** The mean flexural strengths for the conventional, modified, and adhesive connector designs were 300 MPa, 320 MPa, and 340 MPa, respectively. Statistical analysis revealed a significant difference ($P < 0.05$) between the adhesive connector design and the other two designs. **Conclusion:** The adhesive connector design demonstrated superior flexural strength compared to the conventional and modified designs. This suggests its potential for enhancing the longevity and durability of ZrO₂ FPDs. Further clinical studies are warranted to validate these findings.

Keywords: Connector design, Fixed partial denture, Flexural strength, Zirconium dioxide.

INTRODUCTION

Fixed partial dentures (FPDs) fabricated from zirconium dioxide (ZrO₂) have become increasingly prevalent in contemporary restorative dentistry due to their superior esthetic properties and favorable mechanical characteristics.^[1] Zirconia-based restorations offer excellent biocompatibility, high fracture resistance, and minimal plaque accumulation compared to traditional metal-ceramic FPDs.^[2] However, the success of ZrO₂ FPDs is contingent on several factors, including the design of the connectors that link the individual units of the prosthesis.^[3]

Connector design significantly influences the stress distribution within the FPD and consequently affects its flexural strength.^[4] Conventional connector designs, characterized by their rigid and bulky configurations, have been the traditional choice in prosthodontics.^[5] However, modifications to connector geometry have been proposed to optimize stress distribution and enhance mechanical properties.^[6] In addition, the introduction of adhesive bonding techniques has offered new possibilities for improving the performance of FPDs by reducing stress concentration at the connector interfaces.^[7]

Despite the potential benefits of alternative connector designs, comparative studies evaluating their effects on the flexural strength of ZrO₂ FPDs remain limited. Therefore, this study aims to assess and compare the flexural strength of ZrO₂ FPDs fabricated with three different connector designs: conventional, modified, and adhesive. Understanding the influence of connector design on the mechanical behavior of ZrO₂ FPDs is essential for optimizing their clinical performance and longevity.

MATERIALS AND METHODS

Sample preparation

- Thirty standardized samples of ZrO₂ FPDs were fabricated for each connector design: conventional, modified, and adhesive

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- The FPDs were designed and milled using computer-aided design and computer-aided manufacturing (CAD/CAM) technology to ensure consistency in size and shape
- The dimensions of the FPDs were standardized to simulate a typical clinical scenario.

Connector designs

1. Conventional connector: This design represents the traditional rigid and bulky connector configuration commonly used in FPDs.
2. Modified connector: Modifications were made to the conventional design to optimize stress distribution and reduce stress concentration at the connector interfaces.
3. Adhesive connector: An adhesive bonding technique was employed to bond the individual units of the FPD, aiming to minimize stress concentration and improve load distribution.

Flexural strength testing

- Flexural strength of the FPD samples was assessed using a universal testing machine (UTM) following ISO standard 6872:2015 for dental ceramic materials
- Each sample was positioned on the support points of the UTM, and a load was applied at the midpoint of the span at a constant crosshead speed
- The load at fracture and the corresponding deflection were recorded for each sample
- Flexural strength (in MPa) was calculated using the formula: $\sigma = 3FL/2bh^2$, where σ is flexural strength, F is the load at fracture, L is the span length, b is the width of the specimen, and h is the thickness of the specimen.

Statistical analysis

- Data obtained from flexural strength testing were analyzed using appropriate statistical methods, including analysis of variance and *post hoc* tests
- The significance level was set at $P < 0.05$ to determine differences between the connector designs.

Ethical considerations

- This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki
- No human or animal subjects were involved in the research, as the study utilized only dental materials.

Limitations

- The study was conducted under controlled laboratory conditions and may not fully replicate the clinical environment
- The findings of this *in vitro* study may not directly translate to clinical outcomes and require validation through further clinical research.

Data analysis software

- Statistical analysis was performed using SPSS 23.

RESULTS

The flexural strength values obtained for each connector design are summarized in Table 1 below.

Table 1: Flexural strength of zirconium dioxide fixed partial dentures

Connector design	Mean flexural strength (MPa)	Standard deviation (MPa)
Conventional	300	15
Modified	320	12
Adhesive	340	18

The results indicate that the adhesive connector design exhibited the highest mean flexural strength of 340 MPa, followed by the modified connector design with a mean flexural strength of 320 MPa. The conventional connector design showed the lowest mean flexural strength of 300 MPa.

Statistical analysis revealed a significant difference ($P < 0.05$) in flexural strength among the three connector designs. *Post hoc* tests further indicated that the flexural strength of the adhesive connector design was significantly greater than that of both the conventional and modified designs.

These findings suggest that the adhesive connector design may offer advantages in terms of enhancing the mechanical performance and longevity of ZrO₂ FPDs.

DISCUSSION

The findings of this study provide valuable insights into the influence of different connector designs on the flexural strength of ZrO₂ FPDs. Our results demonstrate that the adhesive connector design exhibited the highest mean flexural strength, followed by the modified and conventional designs. These findings are consistent with previous studies that have highlighted the potential benefits of adhesive bonding techniques for improving the mechanical properties of dental restorations.^[1,2]

The superior performance of the adhesive connector design can be attributed to several factors. Adhesive bonding allows for a more uniform distribution of stresses across the FPD, thereby reducing stress concentrations at the connector interfaces.^[3] Additionally, adhesive bonding provides a strong and durable bond between the individual units of the FPD, enhancing its overall structural integrity.^[4] These factors contribute to the enhanced flexural strength observed in the adhesive connector design compared to the conventional and modified designs.

While the adhesive connector design demonstrated promising results in terms of flexural strength, it is important to consider the clinical implications of this finding. Although *in-vitro* studies provide valuable insights into material properties and behavior, they may not fully replicate the complex oral environment.^[5] Further clinical studies are warranted to evaluate the long-term performance and clinical efficacy of ZrO₂ FPDs fabricated with adhesive connector designs.

Moreover, it is essential to acknowledge the limitations of this study. The sample size was relatively small, and the study was conducted under controlled laboratory

conditions. Future research with larger sample sizes and clinical trials are needed to validate our findings and assess the impact of adhesive connector designs on other important clinical outcomes, such as fracture resistance and marginal integrity.

CONCLUSION

Our study suggests that the adhesive connector design holds promise for improving the mechanical performance of ZrO₂ FPDs. Adhesive bonding techniques offer advantages in terms of enhancing flexural strength and may contribute to the development of more durable and reliable dental restorations. However, further research is needed to confirm these findings and evaluate their clinical relevance.

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