Influence of connectors on survival of all ceramic fixed partial denture-a narrative review

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Abstract: **The way stress is spread out in a clinical prosthesis can be quite complicated. It can include different types of stress, such as compression (squeezing), tension (pulling apart), shear (sliding forces), or a combination of these, depending on the conditions it's under. Brittle materials like dental ceramics are prone to failure when subjected to tensile stress (Peterson et al., 1998). The connector area can be seen as a factor that increases the risk of fractures because it causes the tensile stress to become more concentrated, especially when the material is under flexural compressive forces. Articles on connector design, position, dimension and all ceramic materials were searched in google scholar, PubMed, Scopus. Then relevant articles were selected and analyzed. The design of connector and dimensions paly a vital role in stress distribution and overall survivability of all ceramic fixed partial denture especially in the gingival embrasure area compared to occlusal embrasure area. Convex connector design helps in better stress distribution than concave connector design.**

Keywords: **connector design, all ceramic material**

INTRODUCTION

The design of a fixed partial denture (FPD) is very important to reduce the stresses generated over the tooth and the surrounding bone structure.[1] The shape of an FPD is not uniform. Its contour has a complex combination of multiple convexities and concavities, depending on the geometry of the teeth and their alignment. Failures occur most often around connector areas between retainers and pontics.[2] Connectors are regions of high stress concentration and, therefore, frequently involve complications. The connector area, especially the gingival embrasure, needs unique conditions due to biological and esthetic demands. they must be well assessed specially in the posterior regions where the loads are much higher (500-600 N) and the clinical crown shorter.1 When occlusal forces are applied directly through the long axis of a FPD at the midspan (pontic), compressive stresses will develop at the occlusal aspect of the connector at the marginal ridge, and tensile stresses will develop at the gingival surface of the connector. These tensile stresses contribute to the propagation of microcracks located at the gingival surface of the connector through the core material in an occlusal direction, and may eventually result in fracture.[3]

Through modification of the connector design in regions where maximum stress occurs, the stress pattern may be altered to improve the fracture resistance of FPDs.so the aim of this narrative review is to asses the design of connector in the survival of FPD.

MATERIALS AND METHODS

Articles on connectors in fixed dental prostheses were searched using the keywords" connectors in fpd, influence of design of connectors in fpd, fracture resistance of connector base on different materials, longevity of fpd based on connector size in PubMed/Med line, Scopus, Google Scholar, and Science Direct. Further search criteria included being published in English literature.

Additional literature was identified by screening the reference lists of selected articles to ensure the inclusion of relevant studies.

Inclusion Criteria: Studies published in English, effect of design of connectors, different materials in the survival of fpd. Both clinical and review articles were considered.

Exclusion Criteria: editorials, opinion pieces, and studies lacking clinical relevance or not specifically addressing for survival of fpd based on design and type of connectors in fpd.

CONNECTOR DESIGN

The dimensions, design, and placement of connectors significantly impact the success of a fixed partial denture. Connectors should be large enough to withstand functional forces without bending or breaking, but not so large that they hinder proper plaque control, which can lead to gum problems over time. There should be enough space around the connector, especially near the gum line, to allow for effective cleaning with dental tools. If a connector extends too far from the biting edge toward the gum, it can make oral hygiene difficult, increasing the risk of gum disease and eventual prosthesis failure.

In a buccolingual cross-section, most connectors have an elliptical shape. These elliptical connectors are strongest when the longer axis of the ellipse runs in the same direction as the forces being applied. The design of a fixed partial denture (FPD) isn't uniform; it features a complex shape with various curves, including both convex and concave areas, based on the teeth's geometry and alignment. Specifically, the connector region tends to be narrower for both biological and aesthetic reasons. In 3-unit FPDs, these narrower areas act as points where stress is concentrated more than in other parts of the prosthesis, making them critical in terms of strength and durability.[5-7]

Effect of connector design on the fracture resistance of all-ceramic fixed partial dentures

Anusavice KJ (1996) done in vitro study examined the effect of connector design on the fracture resistance of all-ceramic 3-unit fixed partial dentures (FPDs). Ten specimens were fabricated for each of four connector designs, using a lithia-disilicate-based glass-ceramic core material.

Design I: OE and GE 0.90 mm

Design II: OE 0.90 mm, GE 0.25 mm

Design III: OE 0.25 mm, GE 0.90 mm

Design IV: OE and GE 0.25 mm

Results showed that Design I (0.90 mm OE and GE) had the highest failure load, while Design IV (0.25 mm OE and GE) had the lowest. The gingival embrasure radius significantly impacted fracture resistance, with the failure load increasing by 140% as the gingival radius increased from 0.25 to 0.90 mm. The study suggests that the occlusal embrasure can be sharper for esthetics, as long as the gingival embrasure has a larger radius. Stress concentrations were higher in the gingival region, and smoother, less angled connectors reduced stress. The study concluded that connector geometry, especially at the gingival embrasure, plays a crucial role in the strength of all-ceramic FPDs.[7]

Mai HeshamAbdelrahman(2025)A total of 36 all-ceramic three-unit fixed partial dentures (FPDs) were fabricated using CAD/CAM technology and divided into two groups (n=18) based on connector design. The connector dimensions were standardized at 12 mm.

- Group 1: Convex connector design
- Group 2: Concave connector design

The results showed that monolithic zirconia FPDs can withstand masticatory forces in the molar region, regardless of connector design. However, the convex connector design demonstrated significantly higher fracture resistance than the concave design in full-contoured monolithic zirconia FPDs.[8]

Ali Hafezeqoran (2020) Two groups of twenty 3-unit monolithic zirconia (Sirona inCoris TZI, Sirona Dental Systems GmbH) bridges were fabricated, extending from the mandibular first premolar to the first molar, with different connector sizes (9 mm^2 and 12 mm^2). Each group was further divided into two subgroups with different connector designs (round and sharp). The specimens were subjected to a three-point bending test to determine the fracture-bearing load. Increasing connector dimensions in monolithic zirconia FDPs enhances fracture resistance. Additionally, a sharp embrasure design is not advisable for high-stress areas with limited occlusogingival height.

The recommended 9-mm^2 connector size for a three-unit monolithic zirconia FDP, as suggested by the manufacturer, should be used with caution. In contrast, a 12-mm^2 connector size provides sufficient strength for a three-unit monolithic zirconia FDP, regardless of the embrasure design.[9]

Effect of connector design and material on fracture resistance of all ceramic fixed partial denture

Kwansiri Plengsombut (2009) study evaluated the fracture resistance of different ceramic materials from the IPS e.max system (Ivoclar Vivadent, Amherst, NY). The materials tested included yttrium-tetragonal zirconia polycrystals (IPS e.max ZirCAD) and lithium disilicate glass ceramics (IPS e.max CAD and IPS e.max Press). A total of 30 bar-shaped ceramic specimens were divided into six test groups (n=5):

1. ZirCAD (yttrium-stabilized zirconia) – round connector (ZirCAD-R) and sharp connector (ZirCAD-S).
2. IPS e.max CAD (lithium disilicate) – round connector (CAD-R) and sharp connector (CAD-S).

3. IPS e.max Press (lithium disilicate) – round connector (Press-R) and sharp connector (Press-S).

Two connector designs were used: sharp connectors with a 0.06 ± 0.001-mm radius of curvature, and round connectors with a 0.60 ± 0.01-mm radius of curvature.Results showed that ZirCAD and CAD exhibited significantly higher failure loads with the round connector design compared to the sharp connector design ($P < 0.005$). However, no significant difference in maximum failure load was found between connector designs for the Press groups.

In conclusion, yttrium-tetragonal zirconia polycrystals (ZirCAD) demonstrated higher fracture resistance than lithium disilicate ceramics (CAD and Press). While connector design impacted the fracture resistance of machined ceramics (ZirCAD and CAD), it did not affect pressed ceramics (Press).[10]

Effect of varying the vertical dimension of connectors of cantilever cross-arch fixed dental prostheses in patients with severely reduced osseous support

Manda M (2010) Six digital models were created from a 3D initial model where teeth were prepared for metal-ceramic restorations and splinted with a cross-arch FDP, extended as a 1- or 2-unit cantilever. The vertical dimension (VD) of the connectors near the retaining abutment was set at 3, 4, or 5 mm, and a 3D finite element analysis (FEA) was performed.

Increasing the VD from 3 to 4 mm and from 3 to 5 mm for the connector distal to the retaining abutment reduced the maximum stress by approximately 25% and 48%, respectively. For the mesial connector, the stress reduction was smaller: about 9% and 15% for the 2-unit cantilever and 10% for the 1-unit cantilever with a 4-mm connector. Increasing the VD to 5 mm further did not significantly reduce stress.

The highest stress occurred at the 3-mm distal connector in the 2-unit cantilever restoration, while the connectors proximal to the retaining abutment exhibited the highest stress in all models. Increasing the VD is beneficial for the distal connector, but it has minimal effect on the mesial connector. The 3-mm distal connector in the 2-unit cantilever is at the highest risk of failure.[11]

Influence of Connector Width on the Stress Distribution

S. Mir Mohammad Rezaei (2011) Three models of three-unit bridges replacing the first molar were prepared, with buccolingual connector widths ranging from 3.0 to 5.0 mm. The bridges were loaded with 600 N at a single point on the central fossa of the pontic, at 12 points along the cusp-fossa contact (50 N each), or at eight points along the cusp-marginal ridge contact (75 N each). Alternatively, a 225 N load was applied at a 45º angle from the lingual side.

The results showed that increasing the connector width reduces the failure probability when a vertical or angled load is applied. This understanding of connector width's role can help design dental restorations with lower failure risks.[12]

CONCLUSION

Connectors play a crucial role in the design and functionality of fixed partial dentures, serving as the structural elements that link the various components of the prosthesis. They ensure the distribution of functional forces evenly across the abutment teeth and maintain the stability, retention, and integrity of the FPD. So, the design, position and dimensions of connectors are very important for the long-term survivability of a fixed partial denture.

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