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REVIEW

Stress distribution and flexural strength analysis of anterior ceramic fixed prostheses based on connector designs using finite element analysis

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Keywords: Anterior fixed prostheses, Flexural strength, FEA, Lithium disilicate, Zirconia

ABSTRACT

Background: Anterior ceramic fixed prostheses, such as bridges and resin-bonded fixed partial dentures (RBFPDs), often use zirconia or lithium disilicate. Their success depends on optimal flexural strength and favorable stress distribution to abutment teeth, both influenced by connector design. Objective: This systematic review evaluates the influence of connector design on stress distribution and flexural strength of anterior zirconia and lithium disilicate prostheses using Finite Element Analysis (FEA) or in vitro testing. Methods: Following PRISMA guidelines, studies published between 2015 and 2025 were searched in PubMed, Scopus, and Google Scholar. Eligible full-text English articles examined anterior fixed prostheses made of zirconia or lithium disilicate through FEA or in vitro testing. Results: Seven studies met the criteria. Round connectors in both materials showed the highest flexural strength under oblique loading, while triangular zirconia connectors performed best under vertical loading. Zirconia exhibited uniform stress distribution, whereas lithium disilicate showed balanced stress. Rectangular lithium disilicate connectors displayed more even stress distribution than trapezoidal designs. Double-ended RBFPDs had lower stress than single-ended designs. Conclusion: Connector design and ceramic material critically influence stress distribution and flexural strength in anterior fixed prostheses. (IJP 2025;6(2):157-162)

Introduction

The rehabilitation of anterior tooth loss presents a clinical challenge that requires balancing aesthetic and biomechanical demands. One of the most widely used prosthodontic approaches is the fabrication of fixed dental prostheses in the anterior region using ceramic materials such as zirconia and lithium disilicate. Both materials are known for their excellent optical and physical properties; however, they exhibit fundamental differences in light transmission capability, rigidity, and fracture resistance.[1,2]

Zirconia is a polycrystalline ceramic material with high stress distribution and flexural strength, making it the preferred choice for cases with high occlusal loads. In contrast, lithium disilicate, a silica-based glass ceramic, offers superior translucency and adhesion, making it highly suitable for anterior teeth restorations with high aesthetic demands.[3,4] Although both materials have been extensively used, the success of a three-unit fixed restoration is greatly influenced by the design of the connector the area linking the pontic and the retainer which serves as the load transmission zone.[5]

An improper connector design can lead to excessive stress concentration and ultimately trigger structural failure, especially in anterior teeth that receive complex lateral loading. Therefore, the selection of connector dimensions and geometry becomes an important factor in supporting the mechanical strength of the restoration.[6] In this context, the Finite Element Analysis (FEA) method has become a highly useful numerical analysis tool for evaluating stress distribution in restorative structures non-destructively. Through 3D modeling and masticatory condition simulations, FEA can provide a more accurate representation of the biomechanical response of a restoration design before being clinically tested.[7,8] a highly useful numerical analysis tool for evaluating stress distribution in restorative structures in a non-destructive manner. Through 3D modeling and mastication simulation, FEA provides a more accurate representation of the biomechanical response of a restoration design prior to clinical testing.[7,8]

Several in vitro and FEA studies have examined the relationship between connector design and the type of ceramic material on the stress distribution and flexural strength of a fixed dental prosthesis. However, the findings remain heterogeneous and have not yet produced an optimal connector design for each material type, particularly in anterior fixed dental prosthesis cases.[9] In addition, there are still limited systematic reviews that specifically focus on evaluating stress distribution and flexural strength in anterior fixed dental prostheses made of zirconia and lithium disilicate with varying connector designs using the FEA method.

Based on this background, this systematic review aims to analyze the stress distribution and flexural strength of anterior fixed dental prostheses made of zirconia and lithium disilicate with varying connector designs through finite element analysis and in vitro approaches. This review is expected to provide a strong scientific basis for clinicians in determining the connector design and material of anterior fixed dental prostheses in relation to flexural strength and stress distribution.

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Table 1. Literature search strategy according to PICO criteria

Component	Description
Population (P)	Tooth models with a single anterior tooth loss rehabilitated using a fixed dental prosthesis.
Intervention (I)	Use of zirconia and lithium disilicate materials.
Comparison (C)	Different connector designs.
Outcome (O)	Biomechanical performance in terms of stress distribution and flexural strength of anterior fixed dental prostheses.

Table 2. Summary database

Data Base	First screening based on keywords	Custom Range (2015-2025)	Subject Area	Document type, Source type, Language, Open access	Title screening	Abstract screening	Full text screening
PubMed	39	10	9	8	6	3	3
Google Scholar	101	44	6	6	6	4	4
Scopus	37	15	8	4	4	3	0
TOTAL	177	69	23	18	16	10	7

Table 3. Risk of bias assessment of included studies according to the applied

Appraisal Tools

Article Title	Type of Study	Checklist / Tools Assesment	Conclusion Assesment	Level Quality
Effect of Two Connector Designs on the Fracture Resistance of All-ceramic core materials for Fixed Dental Prostheses: An in- vitro study	In-vitro	JBI Checklist for Quasi- Experimental Studies	Clear objectives, standardized groups and tools, significant results. Model not a clinical form. Worthy of inclusion.	High
Evaluation of Flexural Strength of Zirconia Using Three Different Connector Designs: An In Vitro Study	In-vitro	JBI Checklist for Quasi- Experimental Studies	High compliance with the checklist, few clinical limitations. Suitable for review.	High
Finite Element Analysis (FEA) of the Stress Behavior of Some Dental Materials	FEA	Critical Appraisal Checklist for FEA Studies	The model is very simple, many technical parameters are not explained. It is only suitable as a general reference, not as primary data.	Low
Mechanical Evaluation of Two Different Zirconia- Reinforced Lithium Silicate Ceramics: A Finite Element Analysis	FEA	Critical Appraisal Checklist for FEA Studies	All FEA technical criteria were met, high quality, eligible for systematic review.	High
Optimal design of the retainer and connector for a lithium disilicate resin- bonded fixed dental prosthesis: Finite element and Weibull analyses	FEA	Critical Appraisal Checklist for FEA Studies	The FEA methodology is very robust, with realistic models based on CT scans and comprehensive biomechanical parameters. It is suitable for systematic review.	High
Structural Integrity of Anterior Ceramic Resin- Bonded Fixed Partial Dentures: A Finite Element Analysis	FEA	Critical Appraisal Checklist for FEA Studies	Clinical model based on 3D scanning, complete parameters, valid analysis. Suitable for systematic review.	High
Biomechanical analysis of stress distribution and failure risk in mandibular incisors restored with resin- bonded fixed partial dentures using CAD/CAM materials and restoration designs	FEA	Critical Appraisal Checklist for FEA Studies	An anatomically realistic approach, thorough in material selection and design, and supported by probabilistic failure analysis (Weibull).	High

Review

Literature Search Strategy

This systematic literature review was conducted to analyze the stress distribution and flexural strength of anterior ceramic fixed dental prostheses based on connector design using the Finite Element Analysis (FEA) method. The review was structured according to the PICO framework (Population, Intervention, Comparison, and Outcome), as presented in table 1.

This strategy aimed to critically analyze relevant literature regarding the influence of connector design and ceramic material type on stress distribution and flexural strength in anterior fixed dental prostheses. The Inclusion criteria for this systematic review were: Articles published in English between 2015 and 2025; Studies using anterior fixed dental prosthesis models; Studies involving zirconia and lithium disilicate materials; Evaluations of stress distribution and flexural strength; Studies employing the Finite Element Analysis (FEA) method or in vitro testing; Full-text open access articles. The exclusion criteria were: Review articles, case reports, or descriptive/narrative studies lacking quantitative data; Studies using posterior fixed dental prosthesis models; Articles with restricted access.

Data Selection and Extraction Process

The literature search was systematically conducted through the PubMed, Google Scholar, and Scopus databases. Search terms were developed based on the research question using appropriate keywords combined with Boolean operators (AND, OR, NOT), and quotation marks ("...") were applied to ensure precise search phrases in each database. The Boolean keyword combinations used were as follows, Google Scholar: (("anterior fixed prostheses" OR "anterior bridge" OR "anterior RBFPD") AND ("zirconia" OR "lithium disilicate") AND ("connector design") AND ("finite element analysis" OR "FEA") AND ("flexural strength" OR "stress distribution")) PubMed: (("anterior fixed prostheses[All Fields]" OR "anterior bridge[All Fields]" OR "anterior RBFPD[All Fields]") AND ("zirconia[MeSH Terms]" OR "lithium disilicate[All Fields]") AND ("connector design[MeSH Terms]") AND ("finite element analysis[MeSH Terms]" OR "FEA") AND ("flexural strength[MeSH Terms]" OR "stress distribution[All Fields]")) Scopus: TITLE-ABS-KEY ("anterior fixed prostheses" OR "anterior bridge" OR "anterior RBFPD") AND TITLE-ABS-KEY ("zirconia" OR "lithium disilicate") AND TITLE-ABS-KEY ("connector design") AND TITLE-ABS-KEY ("finite element analysis" OR "FEA") AND TITLE-ABS-KEY ("flexural strength" OR "stress distribution").

The selection process was carried out in two stages. The first stage involved screening based on titles and abstracts, while the second stage consisted of a fulltext evaluation of the selected studies. The assessment was performed independently, and after final confirmation of eligible studies, data were systematically extracted. Extracted data included general information such as publication title, author names, journal source, and year of publication.

Study Selection

The process of literature search and selection was conducted systematically using the established PICO strategy and predefined inclusion and exclusion criteria.

From the initial search results using the keyword strategy developed based on the PICO approach, a total of 177 articles were identified. After further filtering based on publication year (2015–2025),

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Table 4. **Data extraction results**

Research	Type of anterior GTC	Material	Abutment	Connector Design	Method	Result
Sharma et al, 2020	FPD	Yttrium-tetragonal zirconia polycristals, Milled Lithium disilicate glass ceramic and Lost-wax/ heat-pressed lithium disilicate glass ceramic	3 unit all-ceramic FPD anterior	10 rectangular bars with dimensions 30 mm (L) x 5 mm (W) x 5 mm (H) 5 bars are made with sharp curved connectors and 5 bars are made with round curved connectors.	In vitro study	The curved connector design on yttrium-tetragonal zirconia polycrystals and lost-wax /heat-pressed lithium disilicate glass ceramics can be considered as the preferred solid ceramic core materials for FDPs, as they have the highest failure load and flexural strength.
Ahmed, M et al, 2020	FPD	Zirconia	3 unit all-ceramic FPD anterior 11 and 21	Round connector Oval connector Triangle connector	In vitro study	The highest flexural strength was found in triangular connectors with vertical loading and the lowest with oblique loading.
Fransesco, P et al,2025	FPD	Zirconia, lithium disilicate (IPS e.max CAD) dan 3Dprinted composite (Varseosmile crown plus)	(3 unit all-ceramic FPD)	(-)	FEA	Lithium disilicate exhibits a balanced stress distribution and has proven to be a versatile material suitable for anterior restorations and restorations with moderate loads. Its superior aesthetic properties make it an attractive choice for anterior areas.
Botsali, M et al., 2024	1.Tooth-supported anterior crown 2.Tooth-supported posterior crown 3. Tooth-supported 3 unit bridge 4.Implant-supported anterior crown 5.Implant-supported posterior-crown 6.Implant-supported 3-unit bridge	Zirconia-reinforced lithium silicate ceramics	Caninus and Premolar 2	(-)	FEA	Tooth-supported restorations exhibit lower stress distribution values compared to implant-supported restorations of the same type. Stress distribution is higher and more widely distributed across a larger surface area under oblique loading compared to vertical loading. Overall, the stress distribution generated in the single crown model is higher than the stress generated in the bridge model. The implant-supported bridge model under oblique loads shows the highest stress distribution. However, neither the zirconia-reinforced lithium silicate milling nor the pressed form affects the stress concentration area and distribution.
Liu, Y et al., 2025	Resin Bonded Fixed Partial Denture (RBFPD) cantilever design	Lithium disilicate	Caninus	Rectangular and trapezoid	FEA	The shape of the connector, the type of retainer, and the placement of the retainer affect the RBFPD stress distribution, and the lowest stress distribution is observed in the rectangular group. The Labial Contact-RBFPD group showed the lowest maximum principal stress distribution (348.2 MPa) and minimum principal stress (49.1 MPa) under regional loading and the lowest equivalent stress (273.4 MPa) and maximum principal stress (356.0 MPa) with a protrusive position. The Labial Veneer RBFPD group showed the lowest equivalent stress (52.0 MPa), the lowest maximum principal stress (47.5 MPa) and the lowest minimum principal stress (1.04 MPa) at the maximum intercuspal position, the lowest minimum principal stress (1.04 MPa) at the protrusive position, and the lowest equivalent stress (46.7 MPa) at the lateral position.
Osman, M et al., 2023	Resin Bonded Fixed Partial Denture (RBFPD) cantilever design	Lithium disilicate dan zirconia	Central Incisor	Rectangular and trapezoid	FEA	The Palatal Veneer-RBFPD group showed the lowest equivalent stress (268.5 MPa) under regional loading and the lowest maximum principal stress (37.7 MPa) and minimum principal stress (2.02 MPa) under lateral loading. Higher loads indicate greater maximum equivalent stress distribution on both materials, regardless of connector width and shape. Loads of 200 N and 150 N simulated on lithium disilicate prostheses with various shapes and dimensions resulted in connector fracture. In contrast, loads of 200 N, 150 N, and 100 N with rectangular connectors simulated on zirconia were able to withstand the load. However, two trapezoidal zirconia connectors were unable to withstand the load and resulted in fracture.
Wang, H et al., 2024	Resin Bonded Fixed Partial Denture (RBFPD)	1.IPS e.max CAD 2.IPS e.max ZirCAD 3.Vita Enamic 4.Lava Ultimate Vitablocs MarkII	Left & right central incisor mandibula	Single ended & double ended	FEA	Oblique loading produces the highest stress and displacement for single-ended RBFPDs. Lava Ultimate has the largest displacement and main stress distribution, while IPS e.max ZirCAD shows the highest equivalent stress distribution. IPS e.max CAD shows the lowest displacement and main stress among double-ended RBFPDs under oblique loading.

document type, English language, and openaccess availability, 18 articles were deemed eligible for further review.

The first screening stage was carried out based on the article titles, resulting in 16 articles. Subsequently, a comprehensive abstract review was performed, yielding 10 articles that were considered relevant and met the criteria for full-text evaluation. After the final assessment for eligibility according to the inclusion and exclusion criteria, seven articles were found to meet all requirements and were ultimately included in the final analysis, which is presented in table 2.

The PRISMA 2020 flow diagram was utilized in this study to illustrate the article selection process in a transparent and systematic manner. The diagram outlines the stages of identification, screening, eligibility

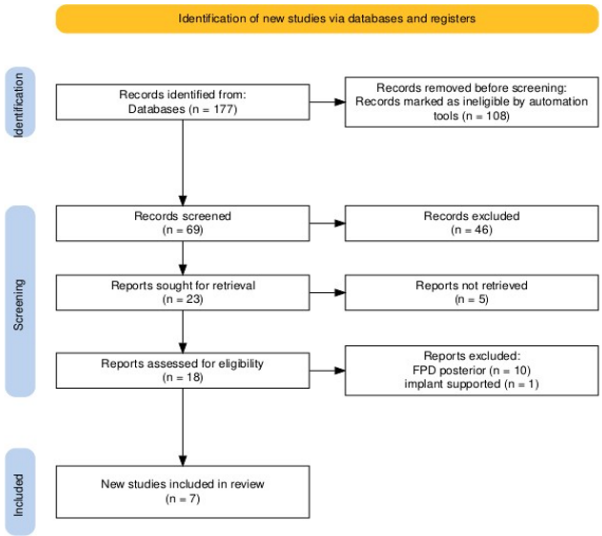

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses)

assessment, and final inclusion of studies that met the criteria for qualitative analysis. Screening was performed based on the predefined inclusion and exclusion criteria, while also considering the methodological rigor and relevance of each study to the objectives of this systematic review. The complete literature selection process is presented in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram below.

Quality Assessment

Methodological quality assessment was performed on all articles included in this systematic review to evaluate the risk of bias and the appropriateness of data for further synthesis. The assessment instruments were adapted according to the type of study being reviewed. For in vitro studies, the JBI Checklist for QuasiExperimental Studies was applied, as it is appropriate for evaluating nonrandomized laboratory experiments. Meanwhile, for Finite Element Analysis (FEA) based studies, the Critical Appraisal Checklist for FEA Studies was used. This checklist was structured based on biomechanical validity principles, including geometric model accuracy, material property validity, boundary conditions, mesh quality, and transparency in discussing methodological limitations.

The seven included studies, five were FEA based and two were in vitro studies. The quality assessment results indicated that most studies demonstrated high methodological quality, meeting nearly all relevant evaluation parameters.

This assessment provides an essential foundation for weighting the evidence of each study during the data synthesis and final interpretation stages. The detailed quality appraisal results are presented in Table 3 below.

Data Synthesis

In analyzing anterior ceramic fixed dental prostheses particularly regarding connector design and material type a comprehensive synthesis was conducted based on seven published scientific studies. These studies employed various methods, including Finite Element Analysis (FEA), in vitro testing, and dynamic loading simulations, to evaluate stress distribution and flexural strength in zirconia- and lithium disilicate–based fixed dental prostheses.

Various connector designs, such as round, triangular, oval, and sharp, were investigated. The findings revealed that both the shape and cross-sectional area of the connector significantly influence stress concentration and flexural strength. The triangular connector design demonstrated the highest flexural strength under vertical loading, while the sharp-edged connector exhibited the lowest strength under oblique loading conditions.

While zirconia showed a more uniform stress distribution and superior longterm durability, lithium disilicate provided a better balance between stress distribution and esthetics, making it the preferred material for restorations in the anterior region.

Overall, these findings emphasize that optimizing connector design particularly in terms of height, geometry, and dimensions is a key factor in determining the long-term clinical success of anterior ceramic fixed dental prostheses.

Result

Among the included studies, five studies (71%) analyzed stress distribution in anterior ceramic fixed dental prostheses using the Finite Element Analysis (FEA) method. These studies included those conducted by Francesco et al. (2025), Botsali et al. (2024), Osman et al. (2023), Wang et al. (2024), and Liu et al. (2025). The results of these investigations consistently indicated that the stress distribution pattern is strongly influenced by connector design, loading direction, and material properties. Connector designs with rounded or rectangular cross-sections consistently reduced stress concentration in the cervical area of the pontic compared with sharp or angular designs, leading to a more even distribution of occlusal forces across anterior ceramic bridges.[5,11,13-15]

Conversely, only three studies (43%) focused on evaluating the flexural strength of ceramic restorations, including those conducted by Sharma et al. (2020), Ahmed et al. (2020), and Osman et al. (2023). The smaller number of studies addressing flexural strength, compared to those examining stress distribution, can be scientifically explained by methodological differences between destructive in vitro testing and FEA simulations. Flexural strength tests require standardized physical specimen fabrication and load-to-failure testing, which are subject to high variability and limited clinical representation. In contrast, the FEA approach allows for non-destructive simulations with broader

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variations in design parameters, connector geometry, and material types, making it a more commonly employed method in modern ceramic prosthodontic research.[10,12,13]

Regarding the loading direction, five studies (71%) Ahmed et al. (2020), Botsali et al. (2024), Osman et al. (2023), Wang et al. (2024), and Liu et al. (2025) investigated oblique loading. Most of these studies reported that oblique loading produced higher maximum equivalent stress values and greater deformation compared to vertical loading, thereby increasing the risk of fracture in the connector and pontic regions. These findings underscore the importance of considering the direction of occlusal forces in the design of anterior prostheses, particularly in cases involving eccentric contacts or lateral loading.[5,10,13-15]

In addition, five studies (71%) also analyzed vertical loads on restorations, including Ahmed et al. (2020), Francesco et al. (2025), Botsali et al. (2024), Wang et al. (2024), and Liu et al. (2025). Vertical loading generally results in a more localized stress distribution around the connector, with lower equivalent stress values compared to oblique loading. These combined results indicate that loading conditions have a direct influence on the mechanical behavior of ceramic prostheses and should be an important variable in connector design.[5,10,13-15]

Discussion

Anterior fixed dental prostheses (FDPs) have high aesthetic and functional demands, making the selection of materials and prosthesis design crucial for longterm clinical success. Based on the synthesis of the seven systematically reviewed studies, it was found that both ceramic material type and connector design significantly influence stress distribution and flexural strength of anterior restorations ceramic anterior fixed denture.

The stress distribution in fixed dental prostheses (FDPs) and resin-bonded fixed partial dentures (RBFPDs) is greatly influenced by the material type and connector design used. Based on Finite Element Analysis (FEA) and in vitro studies, it was observed that round, rectangular, and triangular connector designs provided more uniform stress distribution compared to the oval design. The study by Francesco et al. (2025) reported that lithium disilicate demonstrated a wellbalanced stress distribution. Botsali et al. (2024) found that tooth-supported FDPs exhibited lower stress values than implant-supported FDPs. Meanwhile, Osman et al. (2023) indicated that rectangular connectors simulated in zirconia could withstand higher loads, whereas two trapezoidal zirconia connectors failed under similar conditions, resulting in fracture.[5,11,13]

According to Wang et al. (2024), oblique loading produced the highest stress values in single-ended RBFPDs and the lowest in double-ended RBFPDs. Liu et al. (2025) also reported that connector shape, retainer type, and retainer position influenced stress distribution within RBFPDs.[14,15] The lowest stress values were found in the group with rectangular connectors, particularly those featuring a rectangular cross-section with rounded concavities, which effectively reduced stress concentration in the cervical pontic area, thereby decreasing the risk of fracture.[12,14] This is in line with the theory that states that geometric changes such as sharp angles, small curves, small radius in the embrasure area of the connector often causes stress concentration, where the local stress values are significantly higher than the average stress across the section. This phenomenon, known as the notch effect, is a primary cause of crack initiation in ceramic restorations. A small radius (sharp curvature at the connector) increases tensile stress, thereby facilitating crack initiation and accelerating fracture failure. In contrast, a larger radius or more rounded connector cross-section reduces stress concentration and enhances fracture resistance.

From the material perspective, zirconia demonstrates superior structural resistance under both vertical and oblique loads, with lower equivalent stress values compared to lithium disilicate, particularly under oblique loading (Wang et al., 2024; Francesco et al., 2025). However, lithium disilicate exhibits a more balanced stress distribution and biomechanical behavior better suited for the anterior region, making it the material of choice for cases with high esthetic demands.[11,13,15]

The flexural strength of anterior ceramic restorations also varies significantly depending on the material type, connector design, and type of fixed dental prosthesis. Ahmed et al. (2020) found that in zirconia, the triangular connector design exhibited the highest flexural strength under vertical loading, whereas the round design performed better under oblique loading. This finding indicates that connector geometry should be adapted to the dominant direction of occlusal forces. Similarly, Sharma et al. (2020) reported that yttria-stabilized tetragonal zirconia and lithium disilicate showed distinct mechanical behaviors depending on their structural configuration and loading conditions. Sharma et al. (2020) found that heat-pressed lithium disilicate exhibited the highest failure load and flexural strength compared to the CAD/CAM-fabricated restorations with sharp-edged connectors.[10,12]

This finding is consistent with the theory that flexural strength (σf) refers to the maximum stress achieved on the outer surface fibers of a specimen at the point of fracture during bending. The flexural strength of ceramic restorations is synergistically influenced by several factors, including connector geometry (crosssectional area, moment of inertia, and fillet radius), material properties (Young's modulus, fracture toughness, and transformation mechanisms in Y-TZP), supporting conditions (tooth-supported vs.

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implant-supported), and loading direction (vertical vs. oblique).

From a structural mechanics perspective, the flexural strength capacity of a cross-section is determined by its moment of inertia (I) and cross-sectional area (A). For components such as bridge connectors, increasing the effective cross-sectional area and selecting a shape with a higher moment of inertia—for example, a rectangular section with a wider base or a rounded section with an adequate radius—reduces the maximum tensile stress at the outer fibers during bending of the pontic. Therefore, rectangular or round connectors with sufficient fillet radius demonstrate lower peak stress compared to triangular or sharply notched connectors.

Osman et al. (2023) confirmed that increasing the height of the connector without increasing its width results in greater stress and reduces overall flexural strength. Meanwhile, in the FEA model by Botsali et al. (2024), restorations supported by natural teeth show lower stress and more stable flexural strength compared to implant-supported models, emphasizing the importance of periodontal support in maintaining the mechanical integrity of fixed dentures. Thus, the best flexural strength is obtained in zirconia materials with round and triangular connector designs and rectangular connector dimensions that can withstand occlusal loads without triggering structural failure of anterior ceramic fixed prostheses.[5,13]

Based on the synthesis of literature published between 2020 and 2025, studies employing the finite element analysis (FEA) method consistently demonstrated the influence of connector design and ceramic material type on stress distribution and flexural strength in anterior ceramic fixed dental prostheses.

Findings from Sharma et al. (2020) and Ahmed et al. (2020) revealed that zirconia exhibits superior resistance to high loads and provides a more uniform stress distribution, whereas lithium disilicate offers a balanced stress pattern. Rectangular and round connector designs were consistently associated with reduced stress concentration and enhanced flexural strength in anterior ceramic restorations.[10,12]

Conclusion

This systematic review confirms that the biomechanics of anterior fixed dentures are greatly influenced by the type of ceramic material used, namely zirconia and lithium disilicate, as well as the connector design. Zirconia with a triangular connector design has higher flexural strength compared to round and oval connectors in vertical load applications. Zirconia with a round connector design proved to be superior to triangular and oval connectors in oblique load applications, demonstrating even stress distribution and the highest flexural strength, making it an excellent choice for long-term fixed dental prosthesis restoration. Meanwhile, lithium disilicate with a round connector design shows balanced stress distribution, the highest flexural strength, and high aesthetic properties, making it an attractive choice for anterior fixed dental restorations. The Finite Element Analysis (FEA) approach has been proven to be a tool for accurately analyzing stress distribution and flexural strength, as well as assisting in more optimal dental restoration planning.

References

1. Kelly, J.R. and Benetti, P., 2011. Ceramic materials in dentistry: historical evolution and current practice. Australian dental journal, 56, pp.84-96
2. Zarone F, Ferrari M, Mangano FG, Leone R, Sorrentino R. Digitally oriented materials: Focus on lithium disilicate ceramics. Int J Dent. 2016;2016:9840594.
3. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J 2008;204(9): 505–11.
4. Sasse M, Kern M. CAD/CAM single retainer zirconia ceramic resin-bonded FDPs: Clinical outcome after 5 years. Int J Comput Dent. 2013;16(2):109–18.
5. Botsalı, M., Dikicier, S., Botsalı, H. and Atay, A., 2025. Mechanical Evaluation of Two Different Zirconia-Reinforced Lithium Silicate Ceramics: A Finite Element Analysis. Current Research in Dental Sciences, 35(2), pp.148-153/ doi: 10.17567/currresdentsci.1436067
6. Chen J, Zhu T, Li R, Zhu Z, Pei X, Xu Y, Wan Q. The effects of restorative material and connector cross-section area on the stress distribution of fixed partial denture: a finite element analysis. Head Face Med. 2025;21(1):15
7. Rosentritt, M., Plein, T., Kolbeck, C., Behr, M. and Handel, G., 2000. In vitro fracture force and marginal adaptation of ceramic crowns fixed on natural and artificial teeth. International Journal of Prosthodontics, 13(5).
8. Plengsombut, K., Brewer, J.D., Monaco Jr, E.A. and Davis, E.L., 2009. Effect of two connector designs on the fracture resistance of all-ceramic core materials for fixed dental prostheses. The Journal of prosthetic dentistry, 101(3), pp.166-173.
9. Tinschert, J., Natt, G., Mautsch, W., Augthun, M. and Spiekermann, H., 2001. Fracture Resistance of Lithium Disilicate--, Alumina-, and Zirconia-Based Three-Unit Fixed Partial Dentures: A Laboratory Study. International Journal of Prosthodontics, 14(3).
10. Ahmed, M et al. 2020. Evaluation of flexural strength of Zirconia using three different connector designs: An in vitro study. The Journal of Indian Prosthodontic Society | Published by Wolters Kluwer – Medknow.
11. Francesco, P et al. 2025. Finite element analysis (FEA) of the stress behavior of some dental materials. Journal of Medicine and Life. Vol. 18.
12. Sharma, D et al. 2020. Effect of Two Connector Designs on the Fracture Resistance of All-Ceramic Core Materials for Fixed Dental Prostheses: An In-Vitro Study. Indian Journal of Public Health Research & Development, July 2020, Vol. 11, No. 7.
13. Osman, M et al. 2023. Structural Integrity of Anterior Ceramic Resin- Bonded Fixed Partial Denture: A Finite Element Analysis Study.J. Funct. Biomater. 2023, 14, 108.https://doi.org/10.3390/jf b14020108.
14. Liu, Y. et al. 2025. Optimal design of the retainer and connector for a lithium disilicate resin-bonded fixed partial denture: A finite element analysis study. The Journal of Prosthetic Dentistry.
15. Wang, H et al. 2024. Biomechanical Analysis of Stress Distribution and Failure Risk in Mandibular Incisors Restored with Resin Bonded Fixed Partial Dentures Using CAD/CAM Materials and Restoration Designs. Frontiers in Bioengineering and Biotechnology. 12:1501815. DOI: 10.3389/fbioe.2024.1501815.

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