# STRESS DISTRIBUTION IN LONG SPAN FIXED PARTIAL DENTURE- A LITERATURE REVIEW

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**Article History: Received:** 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

**Abstract**

Dental prostheses are used to replace missing teeth and restore the function and aesthetics of the oral cavity. Fixed partial dentures (FPDs) are a type of dental prosthesis used to replace one or more missing teeth by connecting two or more natural teeth together with artificial teeth. FPDs are designed to withstand the masticatory forces generated during chewing and provide support and stability to adjacent teeth.However, long span FPDs, which replace multiple missing teeth and span a long distance between two or more teeth, can pose a challenge to the dentist due to their increased susceptibility to mechanical failure. Failure of a long span FPD can lead to functional and aesthetic problems and may require expensive and time-consuming repairs or replacement.Therefore, understanding the stress distribution in long span FPDs is essential for their successful design and construction. In this literature review, we will explore the factors that affect stress distribution in long span FPDs and the strategies that can be employed to minimize the risk of mechanical failure.

**Keywords-** Fixed partial denture, mechanical failure, stress distribution, I-T FPD

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**DOI: 10.31838/ecb/2023.12.s2.035**

## 1. Introduction

Prosthodonticsdealswithrehabilitation of edentulism in patientswith loss of teeth due to several reasonssuchascaries,periodontaldiseases,traumaand otherpathologicalconditionsetc.Restorationcanbedoneintermsoffixedprosthesisorremovableprosthesis.Fixedpartialdenturecanimpartsupportfromtheadjacent supportingnaturalteethorimplantsincaseoflongedentulousspanforimprovedretentionandsupport.
Various designs for fixed partialdentureshavebeendescribedwithfixed-fixed, fixed-removable,cantilever,resin-retained,hybrid,specialclinicaldesignsandimplantretainedfixedprosthesishavealsobeendeveloped[1].Thesedesignsallowthetransmissionofverticalocclusalload alongthelongaxisoftheteeth thereby enhancing the success rate oftherestoration.Complexmultiplefixed-removable prosthesis have beenindicatedtorestoredepletedanddecayed teeth, and extensive wear ofthetooth.
Longspanedentulousspacedemands increased abutment strengthfor retention and support compared toconventional short span fixed partialdenture, however the longer the span,greater is the amount of stress causedovertheprosthesisduetoheavyocclusal loading. Many authors haveputforththeconceptofaddingasingleimplant as an abutment to aid in stressdistribution.Althoughmanycontroversieshave beendescribed,tooth-implantsupportedfixedpartialdenture for long span edentulism havealso demonstrated long term prognosisincertaincases[2].Verticalocclusalloading is usually concentrated at thecervicalregionsoftheabutmentsin conventionalprosthesis. Biomechanicalfactorslikeoverload, leverage,torqueandflexinginduceabnormal stress concentrations in theframework increasing the incidence offailuresoflongspanfixedpartialdentures[3] Occlusion,lengthofedentulous span, mobility of abutmentstructure,presenceofmultipleabutments,involvementofretentionfeatures,castorsolderedjointsandthevariousrestorativematerialswidelyinfluencesthe longevityoftheprosthesis.

**Evolution of fixed prosthesis**

Fixed partial dentures (FPDs) have evolved significantly over time. The first attempts at fixed tooth replacement date back to ancient times, where materials such as seashells and animal teeth were used to replace missing teeth. However, these materials were not durable and often led to infections.

In the 18th century, porcelain was introduced as a material for tooth replacement. Porcelain was aesthetically pleasing and had a durable surface, but it was brittle and prone to fracture. In the early 20th century, metal-ceramic restorations were introduced, which combined the strength of metal with the aesthetics of porcelain. Metal-ceramic restorations revolutionized the field of fixed prosthodontics and are still widely used today.[Figure 1]

In recent years, all-ceramic restorations have gained popularity due to their superior aesthetics and biocompatibility[3,15]. All-ceramic restorations are made from materials such as zirconia, alumina, or lithium disilicate and are known for their high strength and fracture resistance. However, all-ceramic restorations may be less durable than metal-ceramic restorations and are more prone to chipping.

Figure. 1. Evolution of fixedprosthesis

**Stress distribution in fixed Prosthesis**

Stress distribution is an important consideration in the design and construction of fixed partial dentures (FPDs). FPDs must be able to withstand the masticatory forces generated during chewing and provide support and stability to adjacent teeth. Failure to distribute these forces evenly can lead to stress concentration in certain areas of the FPD, which can lead to mechanical failure, such as fracture or debonding.

Factors affecting stress distribution in FPDs include the length of the span, the location and number of abutment teeth, the design and material of the FPD, and the occlusal forces generated during chewing.

Long span FPDs are more susceptible to stress concentration compared to short span FPDs. The stress concentration is higher in the areas where the FPD contacts the abutment teeth, and this stress is proportional to the length of the span. Therefore, limiting the length of the span to three or four teeth can help distribute stress more evenly.

The location and number of abutment teeth also play a crucial role in stress distribution. Abutment teeth located at the ends of the span distribute stress more evenly compared to those located in the middle of the span. Additionally, more abutment teeth can help distribute stress more evenly.

The design and material of the FPD also affect stress distribution. FPDs with a rigid design and made of high-strength materials, such as metal-ceramic, distribute stress more evenly compared to FPDs with a flexible design and made of low-strength materials, such as all-ceramic. Additionally, the thickness and cross-sectional shape of the FPD can affect stress distribution[4,5].

Finally, the occlusal forces generated during chewing can also affect stress distribution. A balanced occlusion, where the forces are distributed evenly between the teeth, can help reduce the risk of stress concentration in certain areas of the FPD.[Figure 2]

In summary, stress distribution is an important consideration in the design and construction of FPDs. Strategies such as limiting the length of the span, careful selection of the location and number of abutment teeth, and selecting the appropriate design and material can help distribute stress more evenly and minimize the risk of mechanical failure.

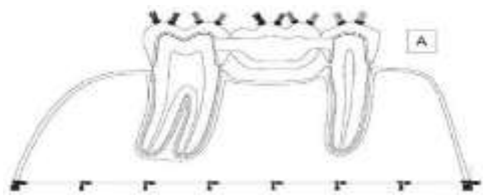
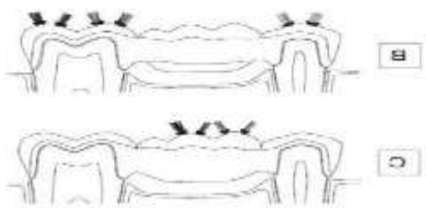



Figure. 2. Stress distribution inFixedpartialdenture(A)Entireprosthesis (B)Abutments (C)Pontic



**Magnitudeof Stressin Fixedprosthesis**

The magnitude of stress in fixed partial dentures (FPDs) can vary depending on a number offactors, including the length of the span, the location and number of abutment teeth, the design and material of the FPD, and the occlusal forces generated during chewing.Studies have shown that the stress in FPDs is highest in the areas where the FPD contacts the abutment teeth. The stress is proportional to the length of the span and increases as the number of missing teeth increases.[Figure 3] Therefore, long span FPDs with fewer abutment teeth are more susceptible to high stress concentrations.The type of material used to fabricate the FPD also affects stress distribution. Metal-ceramic FPDs are typically stronger and more rigid than all-ceramic FPDs, and can distribute stress more evenly. However, they may cause more stress on the abutment teeth due to their increased stiffness. All-ceramic FPDs have lower stiffness and are less likely to cause stress on the abutment teeth, but they may be more prone to fracture.Occlusal forces generated during chewing can also affect the magnitude of stress in FPDs. A balanced occlusion, where the forces are distributed evenly between the teeth, can help reduce the risk of high stress concentrations in certain areas of the FPD[2,5].In order to minimize the risk of mechanical failure, it is important to carefully consider these factors when designing and constructing FPDs. Strategies such as limiting the length of the span, selecting the appropriate design and material, and ensuring a balanced occlusion can help distribute stress more evenly and reduce the risk of high stress concentrations in certain areas of the FPD.

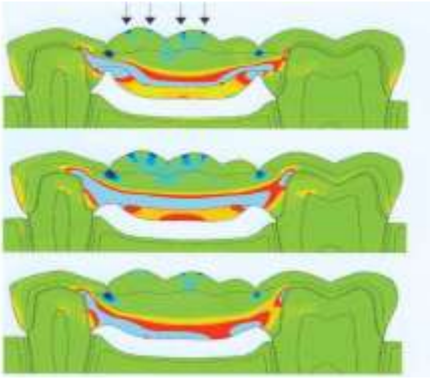


Figure.3.MagnitudeofstressinPontics

**Stress Gauge Measures**

Stress gauge measures are used to measure the magnitude and distribution of stress in fixed partial dentures (FPDs). Stress gauges are small, thin, and flexible devices that can be placed on the surface of the FPD to measure the stress at various points.

There are several types of stress gauges, including electrical resistance strain gauges, photoelastic stress gauges, and digital strain gauges[Figure 4]. Electrical resistance strain gauges measure the deformation of a metal wire under stress and convert it into an electrical signal. Photoelastic stress gauges use a transparent material that changes color when subjected to stress, allowing the magnitude and distribution of stress to be visualized. Digital strain gauges use a semiconductor material that changes resistance when subjected to stress, and the resistance is measured and converted into a digital signal.

Stress gauges can be used during laboratory testing or in vivo studies to measure the stress distribution in FPDs under different conditions, such as varying occlusal loads or different materials[6-8]. This information can be used to optimize the design and construction of FPDs to minimize the risk of mechanical failure.

However, there are some limitations to using stress gauges. They can only measure the stress at the specific points where they are placed, and the readings can be affected by the placement of the gauge and the size and shape of the FPD. Additionally, in vivo studies may be affected by factors such as individual differences in occlusion and chewing patterns, making it difficult to generalize the results to the general population.

Overall, stress gauge measures can provide valuable information about the stress distribution in FPDs, but it is important to interpret the results with caution and consider the limitations of the measurement techiques.

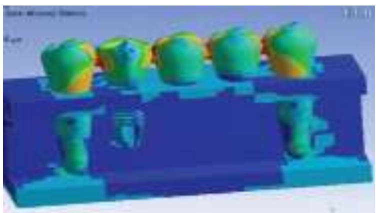


Fig4 Vonmisses stressanalyzer

**Occlusal Influences on Stress Around bridge work**

The occlusal factors can significantly influence the stress distribution around bridgework. The occlusal forces generated during mastication can induce stress on the bridgework and the supporting teeth. Therefore, an understanding of the occlusal factors is essential in the design and construction of fixed partial dentures (FPDs).

One of the main occlusal factors that influence stress distribution is the location and magnitude of occlusal forces. The magnitude of occlusal forces varies between individuals and is affected by factors such as the number and location of missing teeth, the position and inclination of the remaining teeth, and the degree of vertical overlap (overbite) between the upper and lower teeth. High occlusal forces can increase stress on the supporting teeth and the bridgework, leading to potential failure of the restoration[8].[Figure 5]

The distribution of occlusal forces also plays a critical role in stress distribution. A balanced occlusion, where the forces are distributed evenly between the teeth, can help reduce the risk of high

stress concentrations in certain areas of the FPD. In contrast, an imbalanced occlusion, where the forces are concentrated on certain teeth or areas of the restoration, can increase the risk of high stress concentrations, leading to potential failure of the restoration.
The type of occlusal contacts can also influence the stress distribution around bridgework[9]. In a group function occlusion, multiple teeth share the occlusal load, distributing the force across a wider area, and reducing the risk of high stress concentrations. In a mutually protected occlusion, the posterior teeth disclude the anterior teeth during lateral excursions, protecting the anterior teeth and the bridgework from excessive lateral forces.
In summary, the occlusal factors play a significant role in the stress distribution around bridgework. A balanced occlusion, proper occlusal force distribution, and appropriate occlusal contacts are essential in the design and construction of FPDs to minimize the risk of mechanical failure.

**Implant-Tooth fixed prosthesis**

An implant-tooth fixed prosthesis is a type of fixed partial denture (FPD)that replaces missing teeth using a combination of dental implants and natural teeth as abutments. This type of prosthesis is used when one or more teeth are missing and adjacent teeth are healthy enough to support the restoration.The implant-tooth fixed prosthesis offers several advantages over traditional FPDs. By using dental implants, the prosthesis can provide better stability and support, especially in cases where there are multiple missing teeth[10-13]. Additionally, the use of natural teeth as abutments can help preserve the integrity of the adjacent teeth and prevent excessive tooth reduction.[Figure 6]

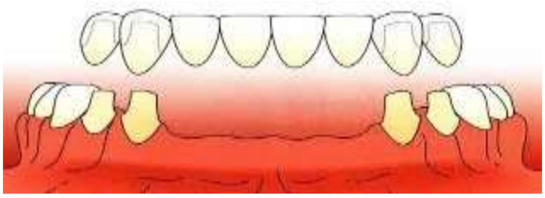


Figure.5Longspanfixedpartialdenture

However, there are some limitations to implant-tooth fixed prostheses. The success of the prosthesis is dependent on the integration and stability of the dental implants, and the presence of gum and bone tissue around the implants. Additionally, there may be some limitations on the number and location of dental implants that can be used based on the patient's jawbone anatomy and overall health.
Overall, implant-tooth fixed prostheses offer a viable option for replacing missing teeth in cases where there are healthy natural teeth adjacent to the missing teeth. The prosthesis provides improved stability and support compared to traditional FPDs and can help preserve the integrity of the adjacent natural teeth.

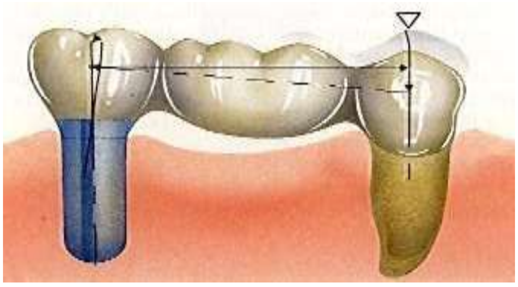


Figure.6 Implant-Tooth fixedprosthesis

**Stress around implant-Tooth Interface**

Stress around the implant-tooth interface is an important consideration in the design and long-term success of an implant-tooth fixed prosthesis. The interface between the implant and the natural tooth can be a potential site for stress concentration, which can lead to mechanical failure of the prosthesis or damage to the supporting structures.
One factor that can affect stress distribution around the implant-tooth interface is the type of connection used between the implant and the natural tooth. There are two main types of connections: rigid and non-rigid. In a rigid connection, the implant and the natural tooth are connected with a solid bar, while in a non-rigid connection, the implant and the natural tooth are connected with a resilient material, such as a silicone or rubber sleeve[9].

Studies have shown that a non-rigid connection can help distribute stresses more evenly along the implant-tooth interface, reducing the risk of stress concentration and mechanical failure. However, a non-rigid connection may also allow more micromovement between the implant and the natural tooth, which can affect the long-term stability of the prosthesis.

Another factor that can affect stress distribution around the implant-tooth interface is the height and width of the implant and the natural tooth. Implants with larger diameters and shorter lengths may distribute stresses more evenly along the implant-tooth interface, reducing the risk of stress concentration. Similarly, natural teeth with larger diameters and shorter roots may be more resistant to stress concentration.

The location and magnitude of occlusal forces can also affect stress distribution around the implant-tooth interface. Implant-tooth fixed prostheses should be designed to distribute occlusal forces evenly along the implant-tooth interface, reducing the risk of stress concentration and mechanical failure.

In summary, stress around the implant-tooth interface is an important consideration in the design and long-term success of an implant-tooth fixed prosthesis. The type of connection used, the height and width of the implant and the natural tooth, and the location and magnitude of occlusal forces are all factors that can affect stress distribution and should be taken into account during the design process[9,12]. [Figure 7-9]

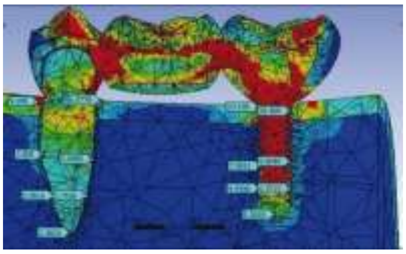


Figure.7Stressanalysisaroundimplant-tooth prosthesis

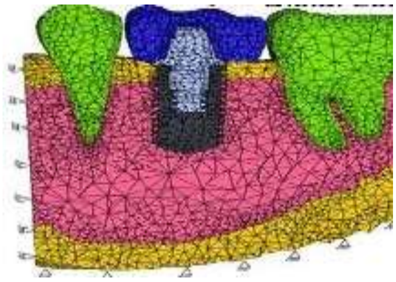


Figure.8 Stress Analysis in toothandimplants.

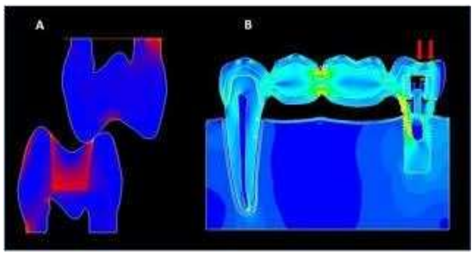



Figure.9 Finite element stressanalysisofimplant-toothfixed prosthesis

**Clinical complications:**

Despite advances in implant dentistry, there are several clinical complications that can arise with implant and tooth-supported fixed prostheses. These complications can result from a variety of factors, including implant or prosthesis design, patient factors, and surgical or restorative technique.

Implant failure: Implant failure is a serious complication that can occur due to a variety of factors, including inadequate osseointegration, implant fracture, or biomechanical overload. Implant failure can lead to prosthesis failure and may require removal of the implant and replacement of the prosthesis.

Peri-implantitis: Peri-implantitis is an inflammatory disease that affects the soft and hard tissues surrounding dental implants. It can lead to bone loss around the implant, which can compromise the stability of the implant and the prosthesis.

Prosthesis fracture: Prosthesis fracture can occur due to a variety of factors, including improper occlusal loading, material fatigue, or design flaws. Prosthesis fracture can result in the need for prosthesis replacement and may compromise the long-term success of the implant or tooth-supported fixed prosthesis.

Screw loosening or fracture: Screw loosening or fracture can occur due to biomechanical overload, inadequate tightening torque, or material fatigue. Screw loosening or fracture can compromise the stability of the prosthesis and may require removal and replacement of the screw or prosthesis.

Cement retention issues: Improper cementation can result in retained cement, which can lead to peri-implantitis, implant or prosthesis failure, or compromised esthetics. Cement retention issues can be minimized by using proper cementation techniques and materials.

Esthetic issues: Esthetic issues can arise due to implant or prosthesis design, surgical or restorative technique, or patient factors. Esthetic issues can include implant visibility, prosthesis misalignment, or poor gingival contour[9,12].

**Occlusal Load Absorption in Tooth-Implant connections**

In tooth-implant-supported fixed prostheses, occlusal load is distributed between the natural teeth and the implant. The connection between the natural teeth and the implant is critical for the overall stability and longevity of the restoration. There are several factors that can influence the occlusal load absorption in tooth-implant connections[14,16]:

Implant position: The position of the implant relative to the natural teeth can influence the distribution of occlusal load. The implant should be placed in a position that allows for even distribution of occlusal forces between the natural teeth and the implant.

Implant diameter and length: The diameter and length of the implant can influence the load-bearing capacity and stability of the implant. Larger diameter and longer implants can offer increased stability and improved load-bearing capacity.

Abutment design: The abutment design can influence the distribution of occlusal forces and load-bearing capacity. The abutment should be designed to distribute occlusal forces evenly and minimize stress on the implant and surrounding structures.

Prosthesis design: The prosthesis design can influence the distribution of occlusal forces and load-bearing capacity. The prosthesis should be designed to distribute occlusal forces evenly along the implant and natural teeth.

Occlusal adjustments: Proper occlusal adjustment is critical for the longevity of the restoration. Occlusal forces should be evenly distributed along the implant and natural teeth to prevent stress on any one component of the restoration.

Overall, the connection between natural teeth and implants in fixed prostheses can absorb occlusal loads and provide stable support for the restoration. Proper implant placement, abutment and prosthesis design, and occlusal adjustments are critical for the successful distribution of occlusal forces and load-bearing capacity of the restoration.

**Zirconia based longs panfdps**

Zirconia-based long span fixed partial dentures (FDPs) have become increasingly popular due to their excellent esthetics, biocompatibility, and mechanical properties. Zirconia is a ceramic material that has high strength, fracture toughness, and resistance to wear, making it an ideal material for dental restorations.

In zirconia-based FDPs, the framework is made of zirconia, which is then layered with porcelain to create a lifelike appearance. The framework can be fabricated using computer-aided design and computer-aided manufacturing (CAD/CAM) technology, which allows for precise and accurate fabrication of the restoration.

Zirconia-based FDPs offer several advantages over traditional metal-based restorations. First, zirconia is a biocompatible material, which means it is less likely to cause adverse reactions in the surrounding tissues. Additionally, zirconia-based restorations offer excellent esthetics, as they can be customized to match the color and translucency of natural teeth. Zirconia also has excellent mechanical properties, which means it can withstand high occlusal forces without fracturing or chipping[10,11].

However, there are some limitations to zirconia-based FDPs. One major limitation is the potential for chipping of the porcelain layer, which can compromise the esthetics of the restoration. Additionally, zirconia can be difficult to bond to the underlying tooth structure, which can affect the overall stability and longevity of the restoration.

Overall, zirconia-based long span fixed partial dentures offer excellent esthetics, biocompatibility, and mechanical properties. However, proper case selection, careful planning, and accurate fabrication are critical to ensure the longevity and success of the restoration.[Figure 10]

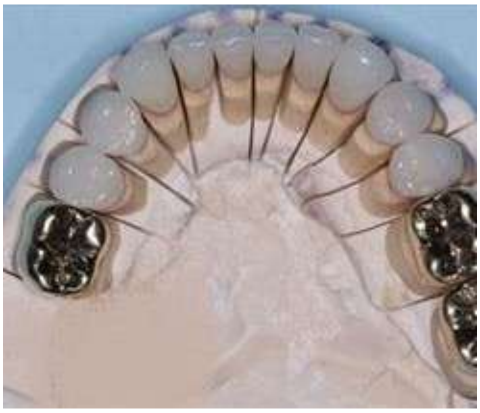


Figure.10LongspanZirconiafixedprosthesis

**Stress Distribution in Adhesive Fixed Partialdentures**

Adhesive fixed partial dentures (AFPDs) are a type of restoration that relies on adhesive bonding to support the prosthesis rather than relying on mechanical retention. AFPDs are typically made of a combination of materials, such as ceramic, composite resin, or zirconia, and are bonded to the tooth structure using adhesive materials.

The stress distribution in AFPDs is influenced by several factors, including the material properties of the restoration and the adhesive system used. The adhesive system plays a critical role in distributing occlusal forces and preventing stress concentrations at the adhesive interface.

One of the advantages of AFPDs is that they distribute occlusal forces more evenly than traditional fixed partial dentures, which rely on mechanical retention. This is because the adhesive layer can deform and absorb some of the forces, preventing them from concentrating at any one point[13,17]. However, if the adhesive bond fails, the forces can become concentrated at the interface, leading to localized stress concentrations and potential failure of the restoration.

Another factor that can influence the stress distribution in AFPDs is the material properties of the restoration. Materials with higher modulus of elasticity, such as ceramics, tend to distribute the occlusal forces more evenly than materials with lower modulus of elasticity, such as composite resins[18].

Overall, AFPDs offer several advantages over traditional fixed partial dentures, including improved stress distribution and reduced risk of damage to the supporting tooth structure. However, careful case selection, accurate fabrication, and proper adhesive technique are critical for ensuring the success and longevity of the restoration.

**Summary**

In summary, the stress distribution in fixed partial dentures (FPDs) is a complex topic influenced by several factors, including the type of restoration, material properties, occlusal forces, and adhesive bonding techniques. Traditional FPDs rely on mechanical retention for stability, while adhesive fixed partial dentures (AFPDs) use adhesive bonding to distribute occlusal forces more evenly. AFPDs offer several advantages over traditional FPDs, including improved stress distribution and reduced risk of damage to the supporting tooth structure. Zirconia-based long span FPDs offer excellent esthetics, biocompatibility, and mechanical properties, but require careful case selection, accurate fabrication, and proper adhesive technique for success. Understanding the biomechanics and stress distribution in FPDs is essential for achieving long-term success and patient satisfaction.

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