ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 9, Issue – 5, October – 2026, Page No. : 06 – 19

Biomechanical Analysis of Tooth- and Implant-Supported Fixed Dental Prostheses with Various Non-Rigid Connector Positions: A Three-Dimensional Finite Element Analysis

[1]Dr. Guneet Chawla, Junior Resident, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

[2]Dr. Tarun Kalra, Professor and Head, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

[3]Dr. Manjit Kumar, Professor, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

[4]Dr. Ajay Bansal, Professor, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

[5]Dr. Shilpa Shirlal, Professor, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

[6]Dr. Abhishek Avasthi, Professor, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

[7]Dr. Ritika Sharda, Assistant Professor, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India.

Corresponding Author: Dr. Manjit Kumar, MDS, Professor, Department of Prosthodontics, Bhojia Dental College and Hospital, Baddi, Himachal Pradesh, India

Citation of this Article: Dr. Guneet Chawla, Dr. Tarun Kalra, Dr. Manjit Kumar, Dr. Ajay Bansal, Dr. Shilpa Shirlal, Dr. Abhishek Avasthi, Dr. Ritika Sharda, “Biomechanical Analysis of Tooth- and Implant-Supported Fixed Dental Prostheses with Various Non-Rigid Connector Positions: A Three-Dimensional Finite Element Analysis”, IJDSIR – October – 2026, Volume – 9, Issue – 4, P. No. 06 – 19.

Copyright: ©2026, Dr. Guneet Chawla, et al. This is an open access journal and article distributed under the terms of the creative common’s attribution non-commercial License. Which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given, and the new creations are licensed under the identical terms.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Statement of Problem: The biomechanical incompatibility between natural teeth and osseointegrated implants remains a concern when both serve as abutments for fixed dental prostheses. Differences in mobility and stress transmission may cause marginal bone loss, implant overload, connector failure, screw loosening, and prosthesis fracture. Although non-rigid connectors may compensate for these differences, the optimal location of their matrix and patrix components remains uncertain.

Purpose: To evaluate and compare stress distribution in tooth-implant-supported fixed dental prostheses with four non-rigid connector configurations under vertical and oblique loading.

Material and Methods: A three-dimensional finite element model of a mandibular second premolar connected to a distal implant replacing the second molar was constructed, with two pontics replacing the first and second molars. Four models were designed: Matrix on Distal of Premolar (MDP), Patrix on Distal of Premolar (PDP), Matrix on Mesial of Implant (MMI), and Patrix on Mesial of Implant (PMI). A 250 N static load was applied vertically and obliquely, and Von Mises stresses were evaluated in the prosthesis, implant, bone, and tooth structures.

Results: Oblique loading produced greater stress concentrations than vertical loading. Connector position significantly influenced stress transmission. Configurations with connectors adjacent to the implant reduced peri-implant stress under selected loading conditions, whereas tooth-adjacent connectors redistributed stress toward the natural abutment.

Conclusions: Connector location significantly affected the biomechanical behavior of tooth-implant-supported prostheses. Appropriate positioning may reduce peri-implant stress and improve biomechanical performance.

Clinical Implications: Proper selection of non-rigid connector location may minimize biomechanical complications, improve restoration longevity, and preserve supporting bone.

Keywords: Finite element analysis, Tooth-implant-supported prosthesis, Non-rigid connector, Dental implant, Stress distribution, Fixed dental prosthesis.

Introduction

Partial edentulism remains one of the most prevalent clinical conditions encountered in prosthodontic practice and significantly affects mastication, phonetics, esthetics, and overall quality of life. Advances in implant dentistry have revolutionized the rehabilitation of partially edentulous patients by providing predictable and long-term treatment options with high survival rates. Nevertheless, several clinical situations continue to present challenges for conventional implant-supported prostheses[1]. Limited bone volume, proximity to vital anatomical structures, systemic contraindications, economic limitations, and patient preference may preclude placement of multiple implants. In such circumstances, connecting a natural tooth with a dental implant to support a fixed dental prosthesis has emerged as a practical treatment alternative[2].

Tooth-implant-supported fixed dental prostheses offer several clinical advantages, including reduced cantilever length, preservation of remaining dentition, improved proprioception through the periodontal ligament, decreased treatment cost, and avoidance of extensive bone augmentation procedures. Long-term clinical studies have demonstrated satisfactory survival rates for these restorations when appropriate biomechanical principles are respected. However, combining a natural tooth and an osseointegrated implant within the same prosthesis introduces a unique biomechanical dilemma because these supporting structures differ fundamentally in their anatomical and functional characteristics[3]. The periodontal ligament surrounding a natural tooth permits physiologic mobility ranging from approximately 50 to 200 μm, whereas the movement of an osseointegrated implant is limited to only a few micrometers because of its direct ankylotic attachment to surrounding bone. This discrepancy results in unequal load sharing during mastication and may produce unfavorable stress

©2026 IJDSIR, All Rights Reserved

concentrations within the implant, surrounding bone, prosthetic framework, and connector regions[4].

Biomechanical overload has been recognized as one of the principal causes of technical and biological complications in implant-supported prostheses. Excessive stress may contribute to screw loosening, porcelain fracture, framework deformation, marginal bone loss, loss of osseointegration, and failure of prosthetic components. Several investigators have therefore proposed modifications in prosthesis design to compensate for the difference in mobility between natural teeth and implants. Among these modifications, incorporation of non-rigid connectors has received considerable attention[5].

Non-rigid connectors function as stress-breaking devices by permitting limited movement between different segments of a fixed dental prosthesis. Unlike rigid connectors that transfer occlusal loads directly across the prosthesis, non-rigid connectors may absorb part of the functional stresses and reduce excessive force transmission to the implant or natural tooth. The connector consists of two components—a female portion (matrix) and a male portion (patrix)—whose relative position influences the direction and magnitude of stress transfer throughout the prosthetic complex[6]. Although non-rigid connectors have traditionally been recommended for pier abutments, their application in tooth-implant-supported prostheses remains controversial because the optimal connector location has not been clearly defined[7].

Finite element analysis (FEA) has become one of the most valuable investigative tools in dental biomechanics. This numerical method enables simulation of complex anatomical structures under controlled loading conditions while allowing detailed assessment of stress and strain within individual components that cannot be measured directly in vivo. Compared with in vitro mechanical testing, FEA provides highly reproducible conditions, facilitates evaluation of multiple prosthetic designs, and enables visualization of stress distribution throughout implants, bone, teeth, and restorative materials. Consequently, finite element analysis has become an indispensable technique for optimizing implant design, connector configuration, occlusal loading, and restorative materials before clinical application[8,9].

Several previous finite element investigations have compared rigid and non-rigid connectors in tooth-implant-supported prostheses. Most studies have demonstrated that non-rigid connectors reduce stress concentration around implants compared with rigid connectors; however, conflicting results remain regarding the most favorable location of the connector components. Furthermore, many available investigations are based on simplified two-dimensional models or evaluate only a limited number of connector designs, restricting their direct clinical application[10].

The present study was therefore undertaken to evaluate four clinically relevant configurations of non-rigid connectors in a three-dimensional tooth-implant-supported fixed dental prosthesis. By analyzing Von Mises stress distribution under both vertical and oblique loading conditions, this investigation aims to identify the connector position that most effectively minimizes stress concentration within the prosthesis and supporting structures. The findings are expected to provide biomechanical evidence that may assist clinicians in selecting the most favorable connector configuration for long-span tooth-implant-supported fixed dental prostheses.

Materials and Methods

©2026 IJDSIR, All Rights Reserved

Study Design

This investigation was designed as a three-dimensional finite element analysis (FEA) to evaluate the biomechanical behavior of tooth-implant-supported fixed dental prostheses with different non-rigid connector (NRC) positions. Four prosthetic designs differing only in connector location were constructed and analyzed under identical loading conditions to determine their influence on stress distribution within the prosthesis and supporting structures. The methodology was adapted from the experimental protocol described in the original thesis.

Three-Dimensional Model Construction

A three-dimensional model of the mandibular posterior segment was generated to simulate a partially edentulous clinical situation extending from the mandibular second premolar to the second molar region.

The model consisted of:

- Mandibular second premolar (natural tooth)
- Periodontal ligament
- Cortical bone
- Cancellous bone
- Two pontics replacing the first and second molars
- Endosseous dental implant positioned in the mandibular second molar region
- Implant abutment
- Full-contour fixed dental prosthesis
- Non-rigid connector

Each component was reproduced using computer-aided design (CAD) software according to anatomical dimensions reported in the literature.

MATERIAL PROPERTIES

All materials included in the finite element model were assumed to be:

- Homogeneous
- Isotropic
- Linearly elastic

Material properties including Young's modulus and Poisson's ratio for cortical bone, cancellous bone, periodontal ligament, titanium implant, prosthetic alloy, and non-rigid connector components were assigned according to previously published biomechanical studies. These assumptions are widely accepted in finite element investigations evaluating implant-supported prostheses and facilitate comparison with previous research.

Prosthetic Models

Four different prosthetic designs were constructed according to the location of the matrix and patrix components of the non-rigid connector.

Model 1 (MDP)

- Matrix positioned on the distal surface of the mandibular second premolar
- Patrix positioned within the mesial aspect of the pontic.

Model 2 (PDP)

- Patrix positioned on the distal surface of the mandibular second premolar.
- Matrix positioned within the mesial aspect of the pontic.

Model 3 (MMI)

- Matrix positioned on the mesial aspect of the implant-supported retainer.
- Patrix incorporated into the distal aspect of the pontic.

Model 4 (PMI)

- Patrix positioned on the mesial aspect of the implant-supported retainer.
- Matrix incorporated into the distal aspect of the pontic.

These four models allowed evaluation of the biomechanical influence of both connector position and

©2026 IJDSIR, All Rights Reserved

orientation while maintaining identical prosthesis dimensions and supporting structures.

MESHING PROCEDURE

The geometric models were imported into finite element software for mesh generation.

Each model was discretized into a large number of tetrahedral solid elements interconnected through nodal points.

Mesh refinement was performed around

- implant neck
- crestal cortical bone
- connector assembly
- pontic-abutment junction

because these regions were expected to experience maximum stress concentration.

Mesh convergence testing was performed before the final analysis to ensure that further refinement produced negligible changes in calculated stress values.

Boundary conditions

To simulate physiological support of the mandible, all degrees of freedom at the inferior border of the mandibular bone were constrained.

Perfect osseointegration between implant and surrounding bone was assumed.

Complete bonding was also assumed between

- Implant and Abutment
- Prosthesis and Abutment
- Natural tooth and Periodontal ligament
- Periodontal ligament and Alveolar bone

No sliding or separation between contacting surfaces was permitted during analysis.

Loading Conditions

Static occlusal loads were applied to each prosthetic model under two different loading conditions.

Vertical Loading

A static vertical load of 250 N was applied perpendicular to the occlusal surface to simulate maximum intercuspation during mastication.

Oblique Loading

A static load of 250 N was applied at an oblique angle representing functional lateral occlusal contacts encountered during mastication.

Oblique loading was selected because previous studies have demonstrated greater stress generation under non-axial loading than under purely vertical loading.

Outcome Measure

The primary outcome variable was Von Mises stress expressed in megapascals (MPa).

Stress distribution was evaluated within

- Prosthetic framework
- Non-rigid connector
- Implant
- Implant abutment
- Cortical bone
- Cancellous bone
- Periodontal ligament
- Natural tooth

Von Mises stress was selected because it is the most widely accepted criterion for evaluating failure risk in ductile biomaterials and has become the standard parameter in dental finite element investigations.

Statistical Analysis

Finite element analysis is a deterministic numerical technique rather than a probabilistic experimental method. Consequently, identical input conditions always produce identical output values.

Therefore, descriptive comparison of Von Mises stress values among the four prosthetic configurations was performed. Maximum stress values and stress contour

©2026 IJDSIR, All Rights Reserved

plots were used to identify regions of stress concentration under both loading conditions.

Results

Finite element analysis demonstrated that the location of the non-rigid connector significantly influenced the pattern and magnitude of stress distribution within the tooth-implant-supported fixed dental prosthesis under both vertical and oblique loading conditions.

In all four models, the highest Von Mises stresses were concentrated around the implant neck, connector assembly, and cervical cortical bone. Oblique loading generated substantially greater stress concentrations than vertical loading irrespective of connector configuration.

Stress contour maps revealed differences in load transfer between the natural tooth and implant depending on the position of the matrix and patrix components.

Effect of Vertical Loading

Under a vertical load of 250 N, stresses were distributed relatively uniformly throughout the prosthetic framework.

The MDP and PDP configurations exhibited higher stress concentrations around the implant-abutment junction compared with the MMI and PMI configurations.

When the connector was positioned adjacent to the implant (MMI and PMI), stress transmission to the implant body and surrounding cortical bone decreased, while a greater proportion of the load was transferred toward the natural tooth.

The periodontal ligament acted as a physiologic stress absorber, reducing localized stress accumulation around the natural abutment.

Effect of Oblique Loading

Application of a 250-N oblique load resulted in considerably higher Von Mises stresses than vertical loading.

Maximum stresses were consistently observed in:

- Implant neck
- Crestal cortical bone
- Connector assembly
- Distal pontic

Stress concentrations increased by approximately two- to three-fold under oblique loading depending on connector configuration.

Among all models, connector placement adjacent to the implant demonstrated improved dissipation of non-axial forces, whereas connector placement adjacent to the natural tooth produced greater stress concentration around the implant.

Comparison among the four connector configurations

Distinct biomechanical behavior was observed among the four prosthetic designs.

Model 1 (MDP)

The matrix-on-distal-premolar configuration generated relatively high stresses around the implant and connector interface during oblique loading. Stress concentration was greatest within the connector assembly and adjacent cortical bone.

Model 2 (PDP)

Reversing the connector orientation redistributed stresses toward the natural tooth while reducing stress within certain implant components. However, localized stress concentration remained evident within the prosthetic framework.

Model 3 (MMI)

Placement of the matrix adjacent to the implant produced a more favorable stress distribution. Implant stresses decreased compared with the premolar-based connector designs, with improved force transmission through the prosthetic framework.

Model 4 (PMI)

The patrix-on-implant configuration demonstrated one of the most favorable biomechanical responses. Stress

©2026 IJDSIR, All Rights Reserved

concentrations were more uniformly distributed, reducing peak stresses around the implant neck while maintaining acceptable stress within the natural tooth.

Prosthetic Framework

The highest stresses within the prosthetic framework occurred near the connector region in every model. Non-rigid connectors effectively interrupted stress transmission across the framework, preventing concentration of excessive forces within a single component. Framework deformation remained within the elastic range for all models.

Implant Components

Peak implant stresses were consistently localized at

- Implant platform
- Implant neck
- Crestal cortical bone

Connector configurations positioned adjacent to the implant reduced stress concentration in these regions compared with premolar-based connector designs.

Natural Tooth

The natural tooth demonstrated physiologic stress distribution through the periodontal ligament. Although connector position altered load transfer, stress values within the tooth remained substantially lower than those observed around the implant. No excessive stress concentration was observed within the root structure.

Cortical and Cancellous Bone

Cortical bone experienced significantly greater stress than cancellous bone under both loading conditions. Stress was concentrated primarily around the crestal cortical bone adjacent to the implant. The cancellous bone showed relatively uniform stress distribution with minimal peak values.

Discussion

Rehabilitation of partially edentulous patients with tooth-implant-supported fixed dental prostheses (TISFDPs) remains controversial because of the fundamental biomechanical differences between natural teeth and osseointegrated implants. Natural teeth are suspended within the alveolus by the periodontal ligament, permitting physiologic mobility and shock absorption, whereas implants are rigidly anchored to bone through osseointegration. This disparity results in different patterns of force transmission during function and may predispose the prosthesis to mechanical and biological complications. Consequently, optimizing connector design is essential to improve the longevity and predictability of tooth-implant-supported restorations[11].

The present finite element analysis demonstrated that the position of the non-rigid connector significantly influenced stress distribution within the prosthesis and supporting structures. Although all four connector configurations successfully transferred occlusal loads, differences in the magnitude and location of stress concentrations were observed, particularly under oblique loading. These findings support the hypothesis that connector location plays an important role in controlling biomechanical behavior[12].

One of the principal findings of this investigation was that oblique loading generated considerably greater Von Mises stresses than vertical loading regardless of connector configuration. This observation is consistent with the biomechanical behavior of implant-supported restorations, as non-axial forces generate bending moments that concentrate stresses at the implant neck and crestal cortical bone. Similar observations have been reported by Pavasiliou et al., Ozcelik et al., Lin et al., and Tsouknidas et al., who demonstrated that oblique occlusal loading is considerably more detrimental than purely axial loading because it increases stress concentration at the cortical crest surrounding the implant. These findings reinforce the importance of

©2026 IJDSIR, All Rights Reserved

establishing mutually protected occlusion and minimizing lateral interferences in implant prosthodontics[13,14,15].

Stress concentration was consistently highest at the implant neck and adjacent crestal cortical bone, irrespective of connector design. This finding agrees with previous finite element investigations showing that the cortical crest functions as the primary region resisting occlusal loads because of its higher elastic modulus compared with cancellous bone. Concentrated stresses in this region have been associated with crestal bone remodeling and marginal bone loss around dental implants. Although finite element analysis cannot directly predict biologic bone remodeling, it provides valuable information regarding regions susceptible to biomechanical overload[16].

The present study further demonstrated that connector position influenced the direction of stress transfer between the implant and the natural tooth. When the connector was positioned adjacent to the implant (MMI and PMI), stresses within the implant and surrounding cortical bone were reduced compared with premolar-based connector configurations. This finding suggests that placing the non-rigid connector closer to the implant permits partial dissipation of functional loads before they reach the implant–bone interface, thereby reducing peak stress concentration[17].

These observations are comparable with those reported by Ozcelik et al., who demonstrated reduced peri-implant stresses when non-rigid connectors were incorporated into tooth-implant-supported prostheses. Kumar et al. similarly reported that flexible connector systems decreased stress accumulation around implants compared with rigidly connected prostheses. Collectively, these investigations indicate that non-rigid connectors may compensate, at least partially, for the differences in mobility between natural teeth and implants[18].

An important aspect of the present investigation was the comparison of matrix and patrix orientation. Although both connector components contributed to stress redistribution, slight differences in stress patterns were observed depending on their position. The PMI configuration demonstrated the most uniform stress distribution among the evaluated models. This may be attributed to the ability of the patrix component to facilitate controlled movement while maintaining adequate prosthetic stability. However, because the differences among implant-based connector configurations were relatively small, clinical factors such as available restorative space, ease of fabrication, retrievability, and laboratory procedures should also influence connector selection[19].

The periodontal ligament played an important biomechanical role by acting as a physiologic stress absorber. Unlike the implant, which transferred occlusal loads directly to cortical bone, the natural tooth distributed stresses through deformation of the periodontal ligament. Consequently, stresses within the tooth remained substantially lower than those surrounding the implant. This observation is consistent with the classic biomechanical concepts proposed by Misch and supports the rationale for preserving healthy natural abutments whenever feasible[20].

Interestingly, incorporation of non-rigid connectors interrupted direct stress transmission through the prosthetic framework. Peak stresses remained localized around the connector region instead of propagating throughout the prosthesis. This stress-breaking effect may reduce the likelihood of catastrophic framework fracture by distributing functional loads more evenly. Similar behavior has been reported in previous

©2026 IJDSIR, All Rights Reserved

investigations evaluating pier-abutment prostheses and long-span fixed dental prostheses incorporating intracoronal attachments[21].

From a clinical perspective, these findings emphasize the importance of individualized prosthesis design rather than universal application of rigid connector systems. Although rigid connectors simplify laboratory procedures and eliminate the possibility of attachment wear, they may transfer greater stresses to the implant–bone interface. Conversely, non-rigid connectors may reduce implant overload but require meticulous fabrication and periodic maintenance. Therefore, selection of connector design should be based on biomechanical requirements, prosthesis span, bone quality, implant position, occlusal scheme, and patient-specific functional demands[22].

The results of the present study should be interpreted in light of the inherent limitations of finite element analysis. All materials were assumed to be homogeneous, isotropic, and linearly elastic, whereas biologic tissues exhibit anisotropic and viscoelastic behavior. Perfect osseointegration and ideal bonding conditions were also assumed, which may not accurately reproduce clinical reality. Furthermore, static loading conditions were evaluated, whereas mastication is a dynamic and cyclic process. Patient-specific variations in bone density, occlusal force magnitude, parafunctional activity, and prosthetic wear were not incorporated into the model. Consequently, finite element analysis should be regarded as a predictive biomechanical tool rather than a direct substitute for clinical trials[23].

Despite these limitations, finite element analysis offers several important advantages. It enables evaluation of stress distribution within structures that cannot be measured directly in vivo, allows standardized comparison of multiple prosthetic designs, and eliminates ethical concerns associated with experimental loading in human subjects. When interpreted alongside laboratory and clinical investigations, finite element analysis provides valuable evidence for optimizing implant prosthesis design[24].

Future research should integrate patient-specific cone-beam computed tomography data, nonlinear material properties, dynamic fatigue loading, and long-term clinical follow-up to validate the biomechanical findings observed in the present investigation. Incorporating digital workflows and artificial intelligence–assisted optimization may further improve connector design and enhance the predictability of tooth-implant-supported restorations[25].

Overall, the present study supports the concept that appropriate positioning of a non-rigid connector, particularly adjacent to the implant, improves stress distribution within tooth-implant-supported fixed dental prostheses. By reducing stress concentration around the implant and promoting more favorable load transfer, such configurations may contribute to improved long-term biomechanical performance and clinical success.

Clinical Implications

Within the limitations of this finite element analysis, the location of the non-rigid connector significantly influenced stress distribution in tooth-implant-supported fixed dental prostheses. Placement of the connector adjacent to the implant demonstrated a more favorable biomechanical response by reducing stress concentration around the implant neck and crestal cortical bone. Appropriate connector selection may therefore decrease the risk of mechanical complications such as screw loosening, framework fracture, porcelain chipping, and marginal bone loss. These findings may assist clinicians in selecting an appropriate connector configuration when rehabilitation with a tooth-implant-supported prosthesis is indicated.

©2026 IJDSIR, All Rights Reserved

Limitations

- Homogeneous and isotropic material properties were assumed.
- Perfect osseointegration was considered.
- Static loading conditions do not replicate masticatory dynamics.
- Bone remodeling and biologic adaptation were not simulated.
- Clinical variables such as parafunctional habits, occlusal wear, and patient-specific bone density were not included.

Conclusions

Within the limitations of this three-dimensional finite element analysis, the following conclusions were drawn:

1. The position of the non-rigid connector significantly influenced stress distribution in tooth-implant-supported fixed dental prostheses.
2. Oblique loading generated substantially greater Von Mises stresses than vertical loading in all connector configurations.
3. Maximum stress concentration consistently occurred around the implant neck and adjacent crestal cortical bone irrespective of connector design.
4. Connector configurations positioned adjacent to the implant demonstrated a more favorable stress distribution compared with premolar-based connector configurations.
5. The PMI (Patrix on Mesial of Implant) configuration exhibited the most homogeneous stress distribution and reduced peri-implant stress concentration among the evaluated models.
6. Non-rigid connectors acted as stress-breaking elements, reducing direct transmission of occlusal forces between the natural tooth and implant.
7. Finite element analysis is a valuable tool for evaluating the biomechanical behavior of implant-supported prostheses and can aid in optimizing prosthetic design before clinical application.

Further laboratory investigations and long-term clinical studies are required to validate these findings under functional oral conditions.

Declarations

Ethical Approval: As this investigation was conducted using a three-dimensional finite element computational model without the involvement of human participants or animals, institutional ethical approval was not required.

Legends Tables

Table 1: Maximum Von Mises Stress Under Vertical Loading (250 N)

Model	Connector Configuration	Region of Maximum Stress	Relative Stress
MDP	Matrix distal to premolar	Implant neck	High
PDP	Patrix distal to premolar	Connector	Moderate-High
MMI	Matrix mesial to implant	Implant neck	Moderate
PMI	Patrix mesial to implant	Connector	Lowest

Table 2: Maximum Von Mises Stress Under Oblique Loading (250 N)

Model	Connector Configuration	Implant Stress	Framework Stress	Overall Distribution
MDP	Matrix distal premolar	Highest	High	Less favorable
PDP	Patrix distal premolar	Moderate	Moderate	Improved
MMI	Matrix mesial implant	Lower	Moderate	Favorable
PMI	Patrix mesial implant	Lowest	Moderate	Most favorable

©2026 IJDSIR, All Rights Reserved

Table 3: Mechanical Properties

Material	Youngs modulus (gpa)	Poissons coefficient
Ti6al-4v alloy	110	0.35
Ni-cr alloy	150	0.26
Cortical bone	15	0.30
Trabecular bone	1	0.25
Prosthesis (coping)	218	0.33

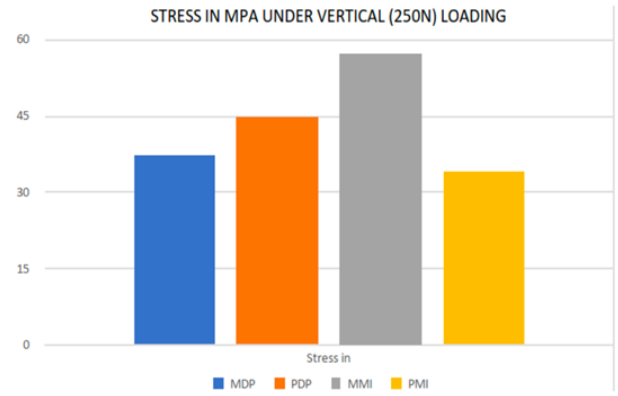
Table 4: max von mises stress (mpa) under vertical load

VERTICAL LOAD	MDP	PDP	MMI	PMI
Stress in MPa	37.245	44.688	57.139	33.94

Table 5: Maximum Von Mises stress (MPa) values under oblique load

OBLIQUE LOAD	MDP	PDP	MMI	PMI
Stress in MPa	11.729	17.224	80.449	82.772

Graph 1: Vertical Load



Graph 2: Oblique Load

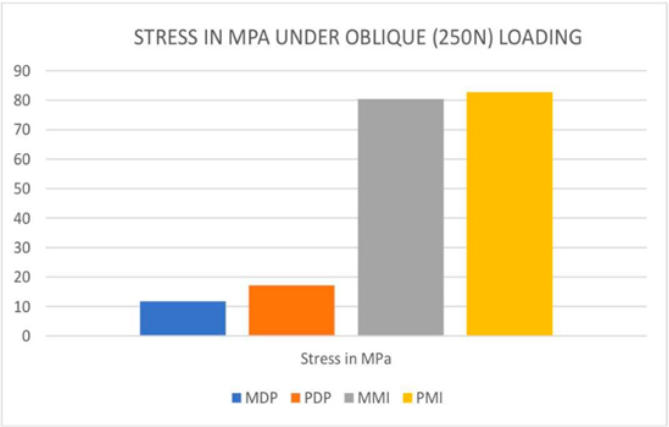


Figure 1: Model Geometry

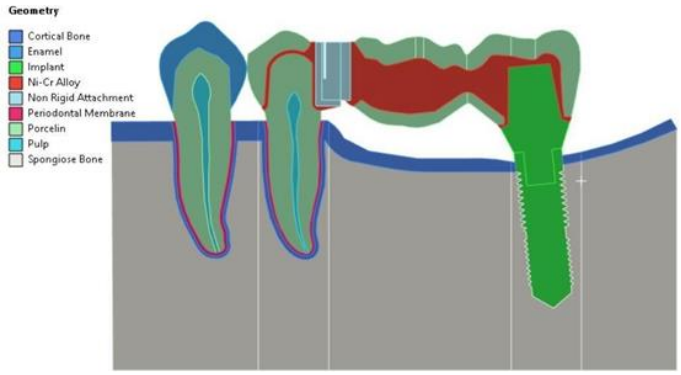


Figure 2: Stress distribution on model MDP (Matrix on Distal of premolar) under vertical load of 250N

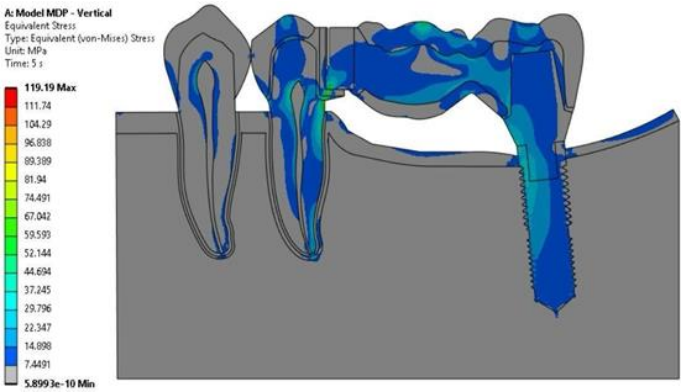
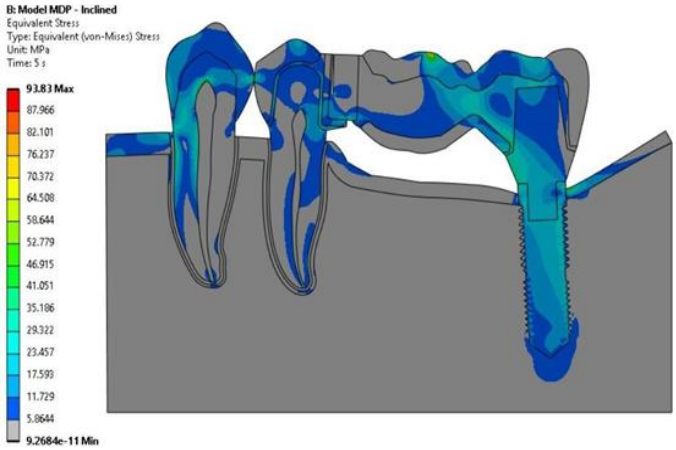


Figure 3: Stress distribution on model MDP (Matrix on Distal of premolar) under inclined load of 250N



©2026 IJDSIR, All Rights Reserved

Figure 4: Stress distribution on model PDP (Patrix on Distal of premolar) under vertical load of 250N

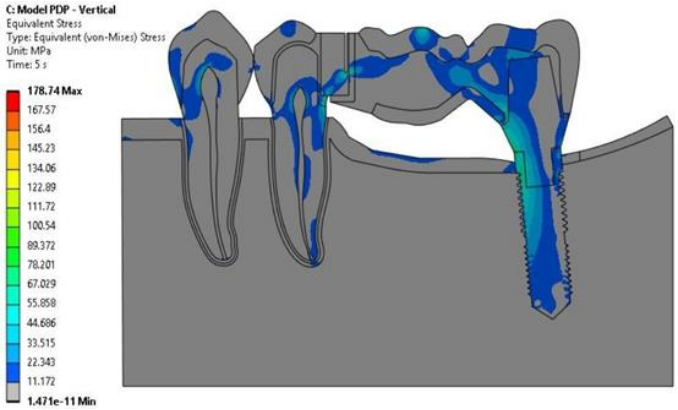


Figure 5: Stress distribution on model PDP (Patrix on Distal of premolar) under inclined load of 250N

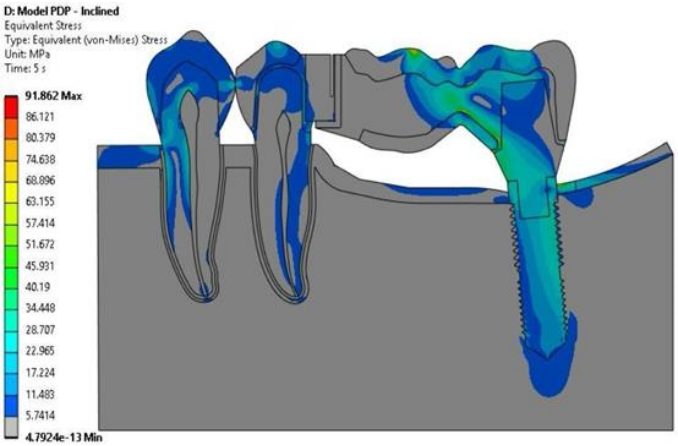


Figure 6: Stress distribution on model MMI (Matrix on Mesial of Implant) under vertical load of 250N

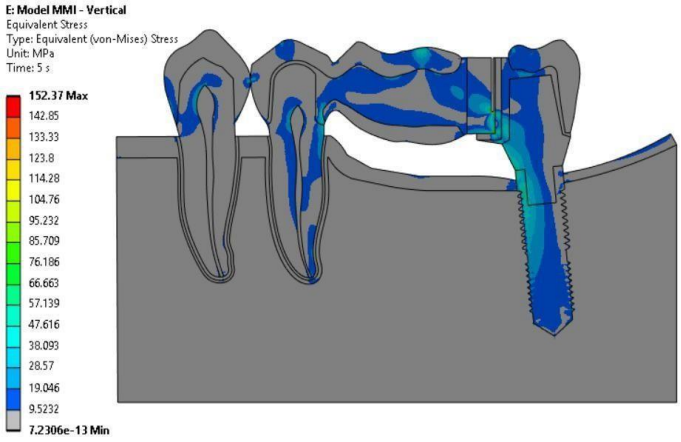


Figure 7: Stress distribution on model MMI (Matrix on Mesial of Implant) under inclined load of 250N

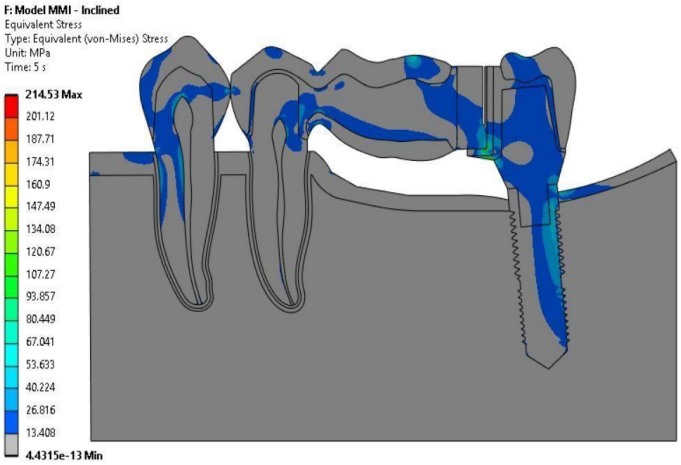


Figure 8: Stress distribution on model PMI (Patrix on Mesial of Implant) under vertical load of 250N

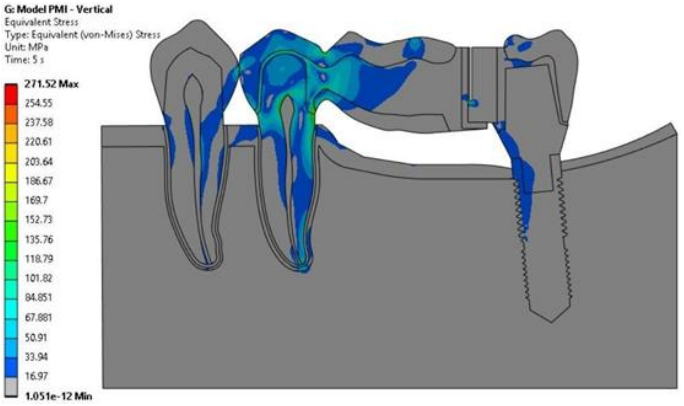
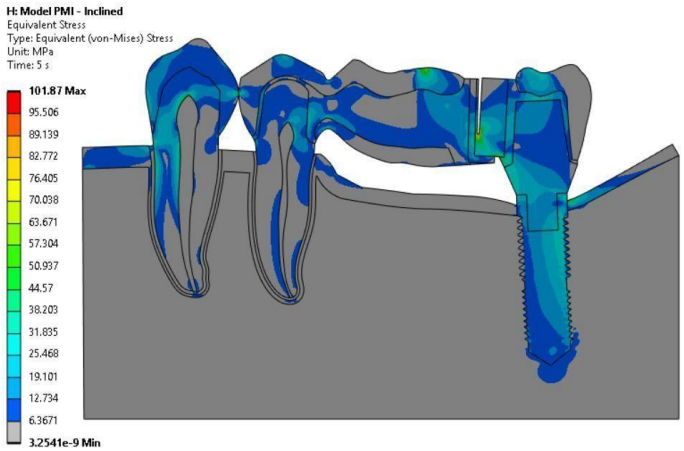


Figure 9: Stress distribution on model PMI (Patrix on Mesial of Implant) under inclined load of 250N



References

1. The Glossary of Prosthodontic Terms: Ninth Edition. J Prosthet Dent. 2017;117(5S):e1-e105.

©2026 IJDSIR, All Rights Reserved

2. Ericsson I, Lekholm U, Brånemark PI, Lindhe J, Glantz PO, Nyman S. A clinical evaluation of fixed bridge restorations supported by the combination of teeth and osseointegrated titanium implants. J Clin Periodontol. 1986;13(4):307-12.
3. Moulding MB, Teplitsky PE. Stress distribution in a fixed partial denture with a pier abutment using rigid and non-rigid connectors. J Prosthet Dent. 1988;60(4):424-9.
4. Rangert B, Jemt T, Jörnéus L. Forces and moments on Branemark implants. Int J Oral Maxillofac Implants. 1989;4(3):241-7.
5. Breeding LC, Dixon DL, Nelson EW, Tietge JD. Tooth-to-implant connection in fixed partial dentures: a biomechanical study. Int J Prosthodont. 1995;8(6):510-5.
6. Pylant T, Triplett RG, Key MC, Brunsvold MA. A retrospective evaluation of endosseous titanium implants in the partially edentulous patient. Int J Oral Maxillofac Implants. 1992;7(2):195-202.
7. Pavasiliou G, Kamposiora P, Bayne SC, Felton DA. Three-dimensional finite element analysis of stress distribution around single tooth implants. J Prosthet Dent. 1996;76(6):633-40.
8. Sheets CG, Earthman JC. Tooth intrusion in implant-assisted prostheses: literature review and case reports. J Prosthet Dent. 1997;77(1):39-45.
9. Pesun IJ. Intrusion of teeth in implant-supported fixed partial dentures: a review. J Prosthodont. 1997;6(2):122-6.
10. DeTolla DH, Andreana S, Paine ML. The finite element method: a review of its applications in dentistry. J Prosthodont. 2000;9(2):126-35.
11. Naert IE, Duyck JA, Hosny MM, van Steenberghe D. Freestanding and tooth-implant connected prostheses in the treatment of partially edentulous patients. Clin Oral Implants Res. 2001;12(3):237-44.
12. Menicucci G, Mossolov A, Mozzati M, Lorenzetti M, Preti G. Tooth-implant connection: finite element analysis versus in vitro experimental validation. Int J Prosthodont. 2002;15(2):177-83.
13. Kronström M, Widbom C, Söderfeldt B. Patient evaluation of treatment with maxillary implant-supported fixed prostheses supported by implants and teeth. Clin Implant Dent Relat Res. 2004;6(1):22-8.
14. Akça K, Uysal S, Cehreli MC. Implant-tooth-supported fixed partial prostheses: two-year prospective study. Clin Oral Implants Res. 2006;17(3):350-6.
15. Özçelik TB, Ersoy AE, Yilmaz B, Biomechanical evaluation of tooth-implant-supported fixed partial dentures with rigid and non-rigid connectors using finite element analysis and photoelastic stress analysis. J Prosthodont. 2007;16(2):107-17.
16. Lin CL, Wang JC, Ramp LC, Liu PR. Biomechanical interactions in tooth-implant-supported fixed partial dentures with rigid and non-rigid connectors: a three-dimensional finite element analysis. Int J Oral Maxillofac Implants. 2008;23(6):1049-55.
17. Özçelik TB, Ersoy AE, Yilmaz B. Stress distribution in tooth-implant-supported fixed dental prostheses with different non-rigid connector positions: a finite element analysis. J Prosthodont. 2011;20(1):16-22.
18. Banerjee S, Banerjee A, Gupta T. Non-rigid connectors in fixed prosthodontics: current concepts with a clinical report. J Indian Prosthodont Soc. 2011;11(4):265-71.
19. Kumar GA, Mahesh B, George R. Stress distribution around tooth-implant-supported fixed prostheses with rigid and non-rigid connectors: a three-dimensional

©2026 IJDSIR, All Rights Reserved

finite element study. J Indian Prosthodont Soc. 2011;11(4):213-8.

20. Koosha S, et al. Three-dimensional finite element analysis of rigid and non-rigid tooth-implant-supported prostheses. J Dent (Tehran). 2013;10(6):534-42.
21. Tsouknidas A, Michalakis K, et al. Effect of bone quality on the biomechanical behavior of tooth-implant fixed partial dentures with rigid and non-rigid connections: a finite element study. Comput Methods Biomech Biomed Engin. 2016;19(14):1527-35.
22. Tsaousoglou P, Michalakis KX, Kang K, Weber HP, Sculean A. The survival and complication rates of tooth-implant supported fixed dental prostheses: a systematic review. Clin Oral Investig. 2017;21(8):2453-63.
23. Paula GA, et al. Biomechanical behavior of tooth-implant-supported prostheses with external and internal implant connections: a three-dimensional finite element analysis. J Prosthet Dent. 2018;120(5):740-7.
24. Mosharraf R, et al. Influence of non-rigid connectors on stress distribution in anterior tooth-implant-supported fixed prostheses: a three-dimensional finite element analysis. J Prosthet Dent. 2021;126(6):827-35.
25. Huang YC, et al. Effect of connector design and implant abutment configuration on stress distribution in tooth-implant-supported prostheses: a finite element analysis. J Prosthet Dent. 2022;128(5):909-17.

©2026 IJDSIR, All Rights Reserved