

## EFFECT OF DENTAL IMPLANTS LOADING AND DESIGN ON STRESS DISTRIBUTION IN A MANDIBLE BONE

## UTICAJ OPTEREĆENJA I DIZAJNA SA ZUBNIH IMPLANATA NA RASPODELU NAPONA U VILIČNOJ KOSTI

Originalni naučni rad / Original scientific paper

Rad primljen / Paper received: 2.12.2025

<https://doi.org/10.69644/ivk-2025-03-0521>

Adresa autora / Author's address:

<sup>1)</sup> University of Belgrade, Faculty of Mechanical Engineering, Belgrade, Serbia A. Sedmak <https://orcid.org/0000-0002-5438-1895>; \*email: [aleksandarsedmak@gmail.com](mailto:aleksandarsedmak@gmail.com)

<sup>2)</sup> Innovation Centre of the Faculty of Mechanical Engineering, Belgrade, Serbia M. Milošević <https://orcid.org/0000-0002-2418-1032>; T. Golubović <https://orcid.org/0000-0001-8283-1104>

<sup>3)</sup> 'Victor Babeş' University of Medicine and Pharmacy, Dept. of Internal Medicine, Timișoara, Romania

<sup>4)</sup> Institute for Information Technologies, Kragujevac, Serbia R. Vulović <https://orcid.org/0000-0002-5545-9965>

### Keywords

- finite element method
- stress distribution
- dental implants
- mandible bone

### Abstract

*The effect of dental implants loading and design on stress distribution in a mandible bone is analysed using the finite element method. Loading is modelled as a single force or as two equal halves. Implants are either separated or connected by a crown. In this way four different cases are presented and analysed in respect to stress distribution in mandible bone. It is concluded that the highest stress appears in separated implants, loaded in a single point, whereas the lowest stress is obtained in connected implants loaded in two points.*

### INTRODUCTION

Finite element method (FEM) is nowadays commonly used to determine stress distribution in any loaded structure, including implants and surrounding mandible, /1-5/. The FEM is used since it can provide detailed insight into different effects, such as splinting and interproximal contact tightness on load transfer by implant restorations, /6/, choice of crown design on load transfer from implant to the bone, /7/, facet material on stress distribution in dental implants, /8/, superstructure, implant length, and mandible height on stress distribution around dental implants, /9/, and implant design and loading simulation on implant stresses, /10/.

### FINITE ELEMENT MODELLING

Physical models of the connected and separated implants are shown in Fig. 1. Both models consist of a block into which the first premolar, second molar, whereas two implants with crowns are inserted at the second premolar and the first molar positions. Assembly of the model with separated implants is presented in 6 stages: 1. first premolar, 2. second molar, 3. implants, 4. crown for the second premolar, 5. crown for the first molar, and 6. final assembly. The tooth model is constructed in two steps. The first step involves the creation of dentin, followed by the construction of enamel in the second step. Other details are given in /10/.

### Ključne reči

- metoda konačnih elemenata
- raspodela napona
- zubni implanti
- vilična kost

### Izvod

*Uticaj opterećenja i dizajna zubnih implantata na raspodelu napona u viličnoj kosti analiziran je primenom metode konačnih elemenata. Opterećenje je modelirano kao jedna sila ili kao dve jednake polovine sile. Implantati su ili razdvojeni ili spojeni krunicom. Na ovaj način su predstavljena i analizirana četiri različita slučaja u pogledu raspodele napona u viličnoj kosti. Zaključeno je da se najveći napon javlja kod razdvojenih implantata, opterećenih u jednoj tački, dok je najmanji napon kod spojenih implantata opterećenih u dve tačke.*

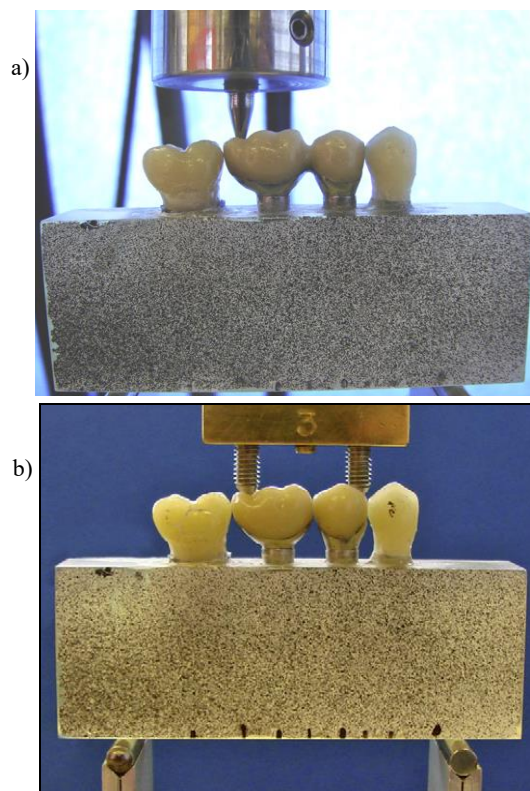


Figure 1. Physical model: a) coupled; b) separated abutments, /10/.

Computational model for connected implants consists of 245317 tetrahedral elements, whereas the model with separated implants has 370669 tetrahedral elements.

Material properties are shown in /7/ for all materials used in this analysis (natural teeth, implants - stainless steel, bone - epoxy resin, support - steel).

## RESULTS AND DISCUSSION

Figures 2-5 show von Mises stress distribution in the bones for these two models and two different force presentations, acting in one or in two points. In case of the model with separate implants, stress is higher in the area of the bone around the second molar root. In addition, higher stresses are located around the implant neck at the tip of the bone. As expected, high stresses occur in the bone area next to the implant top, as well. Since the load is transferred only by implants located at the first molar, stresses also appear in

the bone between the implants, contrary to the model with connected implants, providing more uniform stress distribution. Anyhow, von Mises stress distribution in the implants is similar in both models, although stress values differ. Stress concentration occurs on the implant outer side in contact with the bone, particularly on the implant located at the first molar. This is expected, since the load point is applied on the molar crown.

One should notice also the quantitative differences between four presented maximal stresses. The highest maximal stress is obtained for the model with separated implants and force presented in one point (49.2 MPa), while the lowest stress (6.5 MPa) is obtained for the connected implants and force in two points. In between are maximal stresses for connected implants with force in one point (11.4 MPa) and separated implants with forces in two points (29.0 MPa).

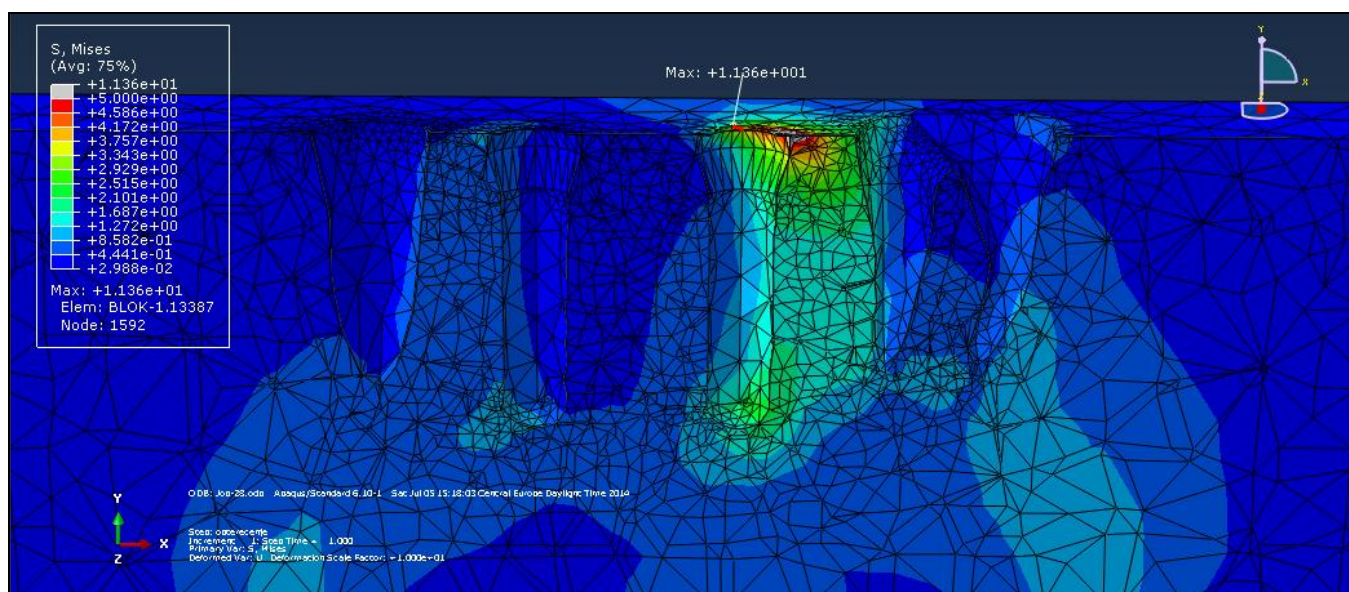


Figure 2. Von Mises stress distribution for connected implants and force in one point.

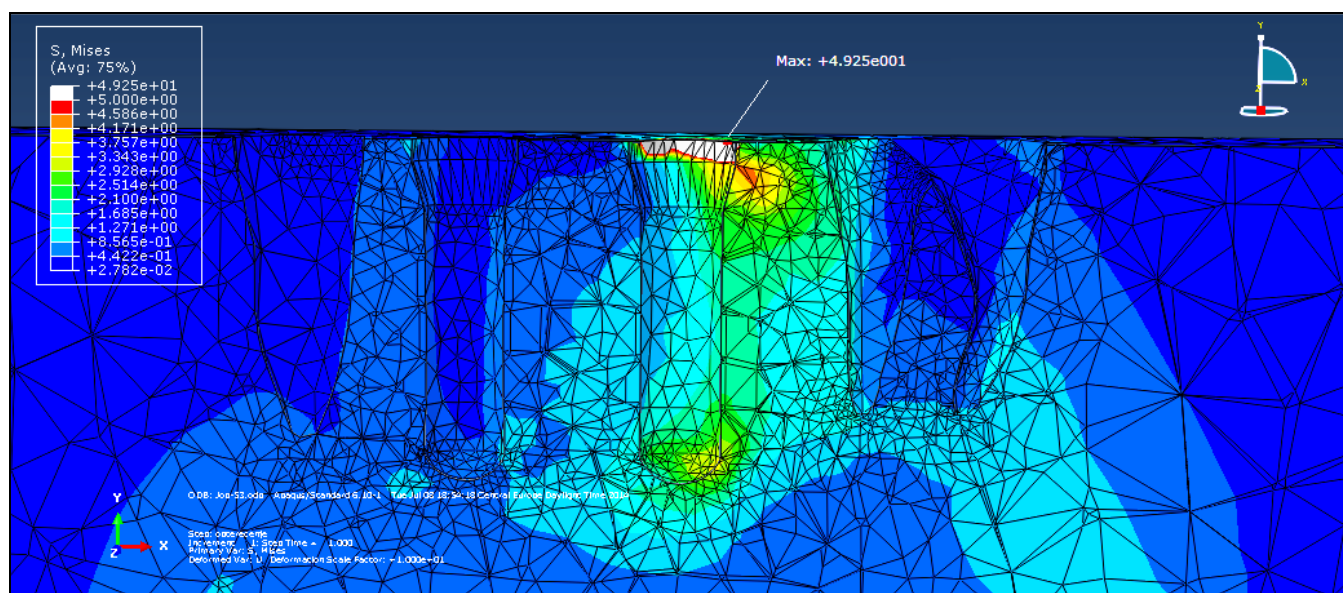


Figure 3. Von Mises stress distribution for separated implants and force in one point.



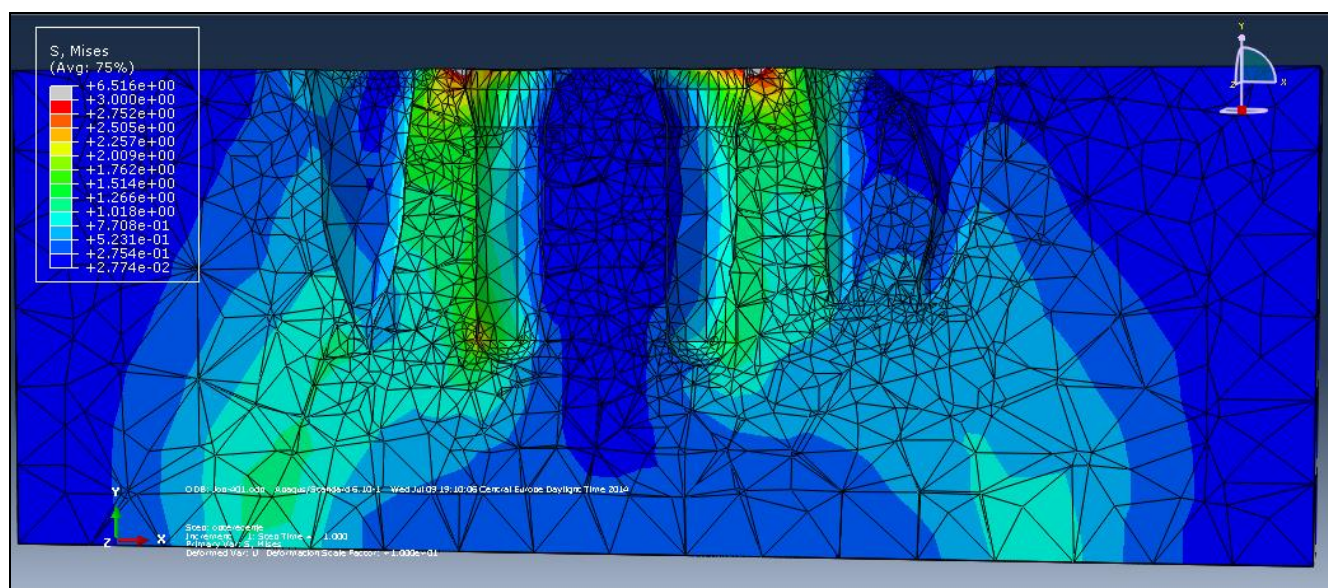


Figure 4. Von Mises stress distribution for connected implants and forces in two points.

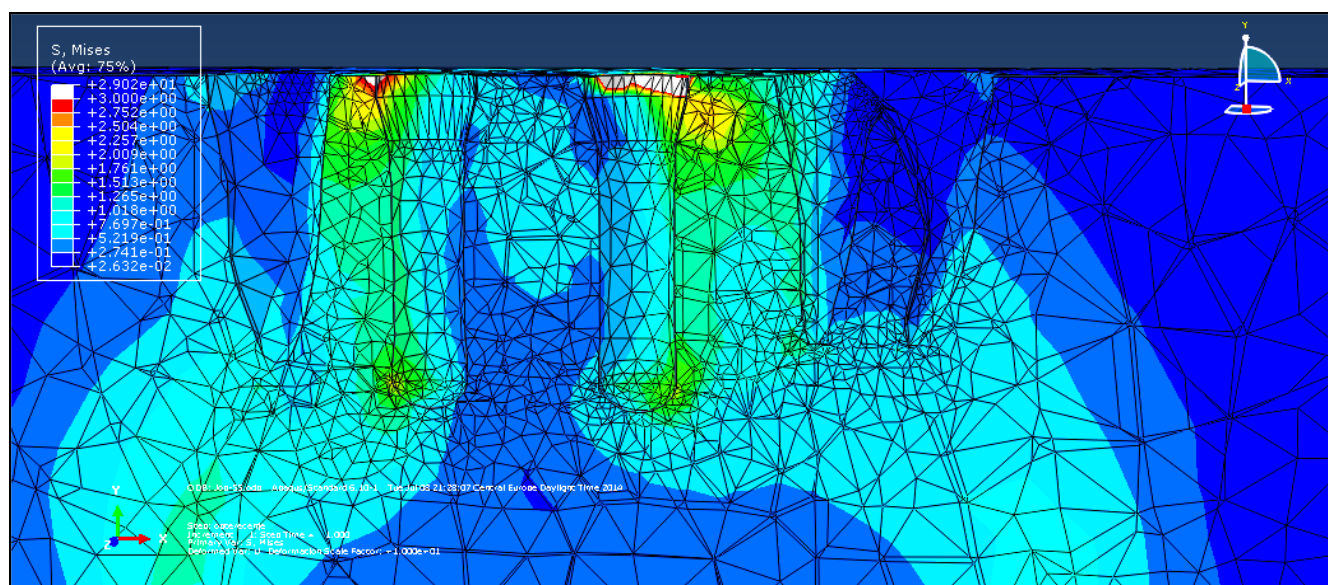


Figure 3. Von Mises stress distribution for separated implants and forces in two points.

## CONCLUSIONS

Based on the results presented in this study, it can be concluded that connecting implants and applying forces at two points significantly reduces maximum stress values in comparison with separated implants and force in one point.

## ACKNOWLEDGEMENTS

The authors would like to thank the support from the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia, under contract No. 451-03-136/2025-03/200213 (from February 4, 2025).

## REFERENCES

1. Cicciù, M., Cervino, G., Bramanti, E., et al. (2015), *FEM analysis of mandibular prosthetic overdenture supported by dental implants: Evaluation of different retention methods*, Comput. Math. Methods Med. Article ID 943839. doi: 10.1155/2015/943839
2. Omori, M., Sato, Y., Kitagawa, N. et al. (2015), *A biomechanical investigation of mandibular molar implants: reproducibility and validity of a finite element analysis model*, Int. J. Implant Dent. 1: 10. doi: 10.1186/s40729-015-0011-5
3. Tiozzi, R., Vasco, M.A.A., Lin, L., et al. (2013), *Validation of finite element models for strain analysis of implant-supported prostheses using digital image correlation*, Dent. Mater. 29(7): 788-796. doi: 10.1016/j.dental.2013.04.010
4. Geng, J.P., Tan, K.B., Liu, G.R. (2001), *Application of finite element analysis in implant dentistry: a review of the literature*, J Prosthet. Dent. 85(6): 585-598. doi: 10.1067/mp.2001.115251
5. Čolić, K., Sedmak, A., Vučetić, N., et al. (2024), *Finite element stress state analysis of mini dental implants*, Struct. Integr. Life, 24(1), 29-32. doi: 10.69644/ivk-2024-01-0029
6. Guichet, D.L., Yoshinobu, D., Caputo, A.A. (2002), *Effect of splinting and interproximal contact tightness on load transfer by implant restorations*, J Prosthet. Dent. 87(5): 528-535. doi: 10.1067/mp.2002.124589
7. Petrović, I., Sedmak, S., Tatić, U., et al. (2014), *Influence of choice of crown design on load transfer from implant to the*

- bone, J Manuf. Industr. Eng. 13(3-4): 1-3. doi: 10.12776/mie.v13i3-4.414
8. Sedmak, A., Milošević, M., Čolić, K., Petrović, I. (2023), *Effect of facet material on stress distribution in dental implants*, Struct. Integr. Life, 23(3): 363-366.
9. Meijer, H.J.A., Kuiper, J.H., Starmans, F.J.M., Bosman, F. (1992), *Stress distribution around dental implants: influence of superstructure, length of implants, and height of mandible*, J Prosthet. Dent. 68(1): 96-102. doi: 10.1016/0022-3913(92)90293-j

10. Sedmak, A., Petrović, I., Milošević, M., et al. (2025), *Digital twin-based numerical simulation of stress distribution in the mandible with dental implants*, Struct. Integr. Life, 25(2): 161-167. doi: 10.69644/ivk-2025-02-0161

© 2025 The Author. Structural Integrity and Life, Published by DIVK (The Society for Structural Integrity and Life 'Prof. Dr Stojan Sedmak') (<http://divk.inovacionicentar.rs/ivk/home.html>). This is an open access article distributed under the terms and conditions of the [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](#)

## ICSMME 2026: 20. INTERNATIONAL CONFERENCE ON STRUCTURAL, MECHANICAL AND MATERIALS ENGINEERING

Miami, United States, March 9-10, 2026

<https://waset.org/conferences-in-march-2026-in-miami>

International Conference on Structural, Mechanical and Materials Engineering aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Structural, Mechanical and Materials Engineering. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Structural, Mechanical and Materials Engineering.

### Topics

Structural Engineering  
Steel Structures: Analysis, Design, and Construction  
Concrete Structures: Analysis, Design, and Construction  
Bridge Engineering  
Road and Railway Engineering  
High-rise Building Structures  
Large-span Bridge Structures

Structural Condition Assessment  
Control of Structures  
Reliability and Durability of Structures  
Structural Rehabilitation, Retrofitting and Strengthening  
Structural Wind Engineering  
Earthquake Engineering  
Novel Hybrid Structural Systems  
Structural Optimization

Mechanical Engineering  
Solid Mechanics  
The Fundamentals of Mechanics and Research Methods  
Structural Dynamics and Vibration  
Fluid Mechanics  
Thermodynamics  
Environmental Mechanics  
Plasticity Mechanics  
Theoretical Mechanics  
Fatigue and Fracture Mechanics  
Materials Engineering

### Special journal issues

20. International Conference on Structural, Mechanical and Materials Engineering has teamed up with the Special Journal Issue on Structural, Mechanical and Materials Engineering. A number of selected high-impact full text papers will also be considered for the special journal issues. All submitted papers will have the opportunity to be considered for this Special Journal Issue. The paper selection will be carried out during the peer review process as well as at the conference presentation stage. Submitted papers must not be under consideration by any other journal or publication. The final decision for paper selection will be made based on peer review reports by the Guest Editors and the Editor-in-Chief jointly. Selected full-text papers will be published online free of charge.



### Committees

Ijan Dangol University of Utah, US  
Poorya Hajyalikhani Tarleton State University, US  
Jay Shen Iowa State University, US  
Issam Harik University of Kentucky, US  
Ali Mehrabian Daytona State College, US  
Tadeh Zirakian California State University, US  
Eduardo Jr Leron University of the East - Caloocan, Philippines  
Saeed Ullah University of Malta, Malta  
Raghabendra Yadav Fuzhou University, China  
Mehran Akhavan Salmassi Islamic Azad University, Semnan Branch, Iran  
Aamer Najim Abbas Mustansiriyah University, Iraq  
Amirreza Masoodi Ferdowsi University of Mashhad, Iran  
S. M. Anas Jamia Millia Islamia, India  
Kenneth Oba Rivers State University, Nigeria  
Huuhue Van Mien Tay Construction University, Vietnam  
Max Magalhaes Federal University of Minas Gerais, Brazil  
Peyman Beiranvand Razi University, Iran  
Abbasali Sadeghi Islamic Azad University, Mashhad Branch, Iran  
Ritu Raj Delhi Technological University, India  
Douangmala Kounsana National University of Laos, Laos  
Bassam Abdulrahman Darbandikhan Technical Institute, Iraq  
Mohammed Rahis Umar City University, Cambodia, Cambodia  
Abdullah Mohamdy Menofia High Institute of Engineering and Technology, Egypt  
Ahmad Alyaseen Shoolini University, India  
Satyajit Das Bhubaneswar Engineering College, India  
Inas Ahmed Northern Technical University, Iraq  
Manish Sharma Jamia Millia Islamia, India  
Ali Biglari-Fadafan Golestan University, United Kingdom  
Anant Parghi National Institute of Technology, India  
Ahad Javanmardi Fuzhou University, China

### Important dates

Abstracts/full-text paper submission deadline: January 6, 2026  
Notification of acceptance/rejection: January 14, 2026  
Final paper (camera ready) submission & early bird registration deadline: January 11, 2026  
Conference dates: March 9-10, 2026