International Journal of Dental Sciences
www.dentaljournal.in
E-ISSN: 2663-4708
Received: 20-11-2025, Accepted: 10-01-2026, Published: 28-01-2026
Volume 8, Issue 1, 2026, Page No. 59-60

Three-dimensional finite element analysis of the mechanical behavior of co-cr and peek clasps in removable partial dentures

Gabriela Lizeth Tabango Cabezas
Faculty of Health Sciences, University of the Hemispheres, Quito, Ecuador

Abstract
This study aimed to compare the mechanical behavior of circumferential and RPI clasps manufactured in cobalt–chromium (Co-Cr) and polyether ether ketone (PEEK) using three-dimensional finite element analysis (FEA). A 2×2 factorial in silico design was applied with four experimental groups (n=16 models). Dislodgement forces, von Mises stresses, and retentive tip displacement were evaluated. Co-Cr clasps showed higher stress concentration and lower displacement, while PEEK clasps exhibited lower stresses with greater elastic deformation. These findings suggest that PEEK is a viable alternative material for removable partial denture clasps in clinical situations requiring reduced stress transmission to abutment teeth.

Keywords: Removable partial denture, finite element analysis, dental clasps, cobalt-chromium, peek

Introduction
Removable partial dentures remain a common solution for partially edentulous patients. The selection of clasp design and material significantly affects retention, stability, and stress distribution. Traditional Co-Cr alloys provide rigidity and retention, while high-performance polymers such as PEEK offer improved biocompatibility and aesthetics. However, their biomechanical behavior requires further evaluation.

Materials and Methods
A 2×2 factorial design was implemented. Four groups were analyzed: circumferential Co-Cr, circumferential PEEK, RPI Co-Cr, and RPI PEEK. CAD models were converted into 3D solids and meshed using tetrahedral elements. Materials were defined as homogeneous, isotropic, and linearly elastic. Dislodgement was simulated with controlled displacement. Von Mises stress and displacement were recorded. Two-way ANOVA was applied.

Results
Co-Cr clasps exhibited higher von Mises stress values (mean 129.86 MPa circumferential; 116.60 MPa RPI) and lower displacement. PEEK clasps showed significantly lower stresses (82.07 MPa circumferential; 73.72 MPa RPI) with greater elastic deformation. Statistical analysis confirmed a significant effect of material.

Discussion
The results confirm that material stiffness is the primary factor influencing clasp biomechanics. PEEK provided adequate retention with lower stress transmission, supporting its clinical application for patients with periodontal compromise or aesthetic demands.

Conclusions
PEEK clasps represent a biomechanically safe alternative to Co-Cr clasps, offering reduced stress concentration with sufficient retention. Co-Cr remains preferable when maximum rigidity is required.

References
1. Alsadon O, Fouda SM, Almutairi Y, Habib SR. The clinical effectiveness of polyetheretherketone (PEEK) prostheses: A systematic review. The Journal of Prosthetic Dentistry,2023:129(2):230–239. https://doi.org/10.1016/j.prosdent.2022.05.010
2. Alvarado AF. Determinación del módulo de Young en aleaciones de cobalto-cromo. Revista Científica, 2008. https://www.redalyc.org/pdf/2312/231218569001.pdf
3. Chen L, Su Y, Shen J, Lin C. Biomechanical analysis of removable partial denture frameworks with different materials using three-dimensional finite element analysis. The Journal of Prosthetic Dentistry,2019:122(3):316–324. https://doi.org/10.1016/j.prosdent.2018.11.010
4. Fuentes R, Arias A, Céspedes O, Navarro P. Biomechanical behavior of removable partial denture frameworks made of polyetheretherketone (PEEK) and cobalt–chrome alloy: A finite element study. Journal of Clinical and Experimental Dentistry,2021:13(4):350–356. https://doi.org/10.4317/jced.57862
5. Gentz FI, Brooks DI, Liacouras PC, Petrich A, Hamlin CM, Ellert DO, *et al*. Retentive forces of removable partial denture clasp assemblies made from polyaryletherketone and cobalt–chromium: A comparative study. Journal of Prosthodontics,2022:31(4):299–304. https://doi.org/10.1111/jopr.13398
6. Güleryüz A, Dede DÖ, Özarslan MM. Comparison of stress distribution of cobalt–chromium and PEEK removable partial denture frameworks with different clasp designs using finite element analysis. Journal of Prosthodontic Research,2022:66(2):242–249. https://doi.org/10.2186/jpr.JPOR_2021_137
7. Hussein MO, Elshamy I, Sherief AH, Naguib GH. Performance of graphene-based and polyether–ether–ketone (PEEK) as esthetic clasp materials for removable partial dentures. Polymers,2022:14(15):2987. https://doi.org/10.3390/polym14152987
8. Kakai RT. Evaluation of retentive forces in three types of removable partial denture framework materials: An

in vitro study. Cureus,2024:16(12):76269. https://doi.org/10.7759/cureus.76269
9. Kim HJ, Oh SH. Effect of clasp designs and material types on the stress distribution of abutment teeth: A finite element study. Journal of Advanced Prosthodontics,2019:11(1):33–41. https://doi.org/10.4047/jap.2019.11.1.33
10. Luo Y, Qiu L, Geng M, Zhang W. Retention and fatigue performance of modified polyetheretherketone clasps for removable prosthesis. Journal of the Mechanical Behavior of Biomedical Materials,2024:154:106539. https://doi.org/10.1016/j.jmbbm.2024.106539
11. Ma Y, Wei X, Wang Z, Sun H, Zhang Y. Finite element analyses of retention and stress distribution of PEEK and Co–Cr clasps in removable partial dentures. Journal of the Mechanical Behavior of Biomedical Materials,2022:135:105249. https://doi.org/10.1016/j.jmbbm.2022.105249
12. Marie A, Keeling A, Hyde TP, Nattress BR, Pavitt S, Murphy RJ, *et al*. Deformation and retentive force following *in vitro* cyclic fatigue of cobalt–chrome and aryl ketone polymer clasps. Dental Materials,2019:35(6):113–121. https://doi.org/10.1016/j.dental.2019.02.028
13. Mayinger F, Micovic D, Schleich A, Roos M, Eichberger M, Stawarczyk B. Retention force of polyetheretherketone and cobalt–chrome–molybdenum removable dental prosthesis clasps after artificial aging. Clinical Oral Investigations,2021:25(5):3141–3149. https://doi.org/10.1007/s00784-020-03642-5
14. Peng T-Y, Su C-C, Hsiao Y-H, Kao H-C. Design optimization of removable partial denture clasp using finite element analysis and Taguchi method. Journal of Prosthodontic Research,2020:64(2):217–223. https://doi.org/10.1016/j.jpor.2019.07.001
15. Richert R, Alsheghri AA, Alageel O, Caron E, Song J, Ducret M, *et al*. Analytical model of I-bar clasps for removable partial dentures. Dental Materials,2021:37(6):1066–1072. https://doi.org/10.1016/j.dental.2021.03.018
16. Rues S, Wiegand A, Urban V, Keßler A. PEEK in prosthodontics: Properties, processing, and clinical applications. Journal of Functional Biomaterials,2023:14(8):416. https://doi.org/10.3390/jfb14080416
17. Sato Y, Abe Y, Akagawa Y. Dimensional measurement and finite element analysis of I-bar clasps. Journal of Oral Rehabilitation,2000:27(11):1064–1071. https://doi.org/10.1046/j.1365-2842.2000.00621.x
18. Sato Y, Abe Y, Akagawa Y. The mechanical properties of I-bar clasps: Finite element analysis. Journal of Oral Rehabilitation,2001:28(4):378–383. https://doi.org/10.1046/j.1365-2842.2001.00673.x
19. Schwitalla AD, Müller W-D. PEEK dental implants: A review of the literature. Journal of Oral Implantology,2013:39(6):743–749. https://doi.org/10.1563/AAID-JOI-D-11-00155
20. Tasaka A, Shimizu T, Kato Y, Okano H, Ida Y, Yamashita S. Accuracy of removable partial denture framework fabricated by casting with a 3D-printed pattern. Journal of Prosthodontic Research,2020:64(2):224–230. https://doi.org/10.1016/j.jpor.2019.07.009
21. Tribst JPM, Dal Piva AMO, Borges ALS, Araújo RM, da Silva JMF, Bottino MA, *et al*. Effect of different materials and undercut on the removal force and stress distribution in circumferential clasps during direct retainer action in removable partial dentures. Dental Materials,2020:36(2):179–186. https://doi.org/10.1016/j.dental.2019.11.022