RESEARCH PAPER

A THREE DIMENSIONAL FINITE ELEMENT ANALYSIS TO EVALUATE THE BIOMECHANICAL EFFECT OF PLATFORM SWITCHING ON IMPLANT-ABUTMENT JUNCTION AND PERI-IMPLANT BONE INTERFACE: AN IN VITRO STUDY

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Abstract

Aim- To evaluate the stress distribution on peri-implant bone, implant-abutment junction as well as prosthetic element with implant supported single crown in platform switching concept with the use of finite element analysis.

Material and method- Three distinct implant-abutment configurations were modelled in three dimensions. A normal 4.3 mm implant (10 mm in length) was attached to a conventional prosthetic component abutment with a diameter of 4.3 mm in the regular platform (RP) group. A large implant (10 mm in length) with a 5 mm prosthetic platform was connected to a standard 4.3 mm diameter prosthetic component to imitate the platform switched (PS) group. In the wide platform (WP) group, a wide implant (10 mm in length) with a 5 mm prosthetic platform was attached to a wide prosthetic component with a 5 mm diameter. These models were imported into finite element software (ANSYS) and occlusal load of 100 N was applied either axial and oblique loads to evaluate the stress distribution.

Result-PS group reduces von mises stress by 22.07 % to 34.11% for axial and oblique loads respectively. In peri-implant bone area cortical bone exhibited higher stress concentration than in trabecular bone.

Conclusion- PS group shows lower stress values in bone, abutment and prosthesis comparatively to RP & WP group. Oblique load results in higher stress concentrations than axial loads for all the models.

Clinical significance: Platform switching demonstrated lower stress concentrations in peri-implant bone and prosthetic components. These findings suggest that platform switching may contribute to improved crestal bone preservation and long-term biomechanical stability of implant-supported restorations.

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Conflicts of interest: There are no conflicts of interest.

Keywords: Dental implants; Platform switching; Finite element analysis; Peri-implant bone; Stress distribution

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Introduction

Implant dentistry has emerged as the most prominent and active area of dentistry during the last few decades. Whether repairing a single tooth or replacing many teeth, the aim of contemporary dentistry is to return the patient to normal shape, function, comfort, aesthetics, speech, and health. The capacity to accomplish this aim despite stomatognathic system atrophy, illness, or damage is what distinguishes implant dentistry.

With thousands of physicians putting and recovering implants made by over 100 implant companies, implant dentistry has grown from little segments of a few clinical practices to a global industry. Implant dentistry demands expertise in every area, including prosthetics, surgery, treatment planning, and patient selection. Implant therapy may be quite difficult when it comes to implant insertion and subsequent restoration in the aesthetic zone. Understanding the crestal bone alterations and the ensuing soft tissue reaction is essential to maintaining the aesthetic expectations. One significant element that has been shown to influence the long-term outcome of dental therapy is crestal bone loss. The marginal bone loss was initially reported by some researchers. Additionally, the study showed that bone loss was more common and of a larger size during the first year of prosthesis loading, averaging 1.2 mm. Instead of measuring bone loss from the first level of crestal bone insertion, which was 1.8 mm above the baseline position, this research used the first thread as the baseline. As a result, an average of 3.3 mm of crestal bone loss surrounding implants was noted in the first year [1]. According to other research, at one year after implant repair, the crestal bone level is usually found between 1.5 and 2.0 mm below the implant-abutment junction [2], but this depends on where the implant-abutment junction is in relation to the bony crest [3].

In 1991, Implant Innovations, introduced 5 mm and 6 mm diameter implants with restorative platforms of the same dimensions [4]. When shorter implants were positioned in cases with reduced bone height, these broad diameter implants were designed to maximise the amount of bone to implant contact. Additionally, in low-quality bone, these wide-diameter implants increased the chance of obtaining primary stability. There was no corresponding prosthetic component available when broad diameter implants were first introduced. For restoration, the physicians employed normal 4.1 mm abutments. In situations where platform switching was used, the normal pattern of crestal bone resorption was not seen radiographically after five years. According to Lazzara and Porter's theory, this happened because the inflammatory cell infiltration was moved and contained within a 90° region that was not immediately next to the crestal bone when the IAJ was shifted inward. Therefore, the use of a smaller diameter abutment on a larger diameter implant collar is referred to as platform swapping. The IAJ's perimeter is moved inward toward the implant's core axis via this connection [5, 6, 7].

Crestal bone loss is decreased in implants with platform switching because the microgap is moved away from the bone and the inflammatory cell infiltration is not near the bone. Lazzara and Porter proposed this theory [7]. Platform swapping may help preserve the height of the crestal bone through the following mechanisms:

Shifting the inflammatory cell infiltrate inward and away from the adjacent crestal bone [8]. Maintenance of biological width and increased distance of IAJ from the crestal bone level [9] [10]. Decreased stress levels in the peri-implant bone [9].

The concept of platform switching can be clinically beneficial to reduce or eliminate crestal bone loss by maintaining better bone-implant contact, superior esthetics and primary stability.

Therefore, the objective of this research was to apply finite element analysis to assess the stress distribution on the peri-implant bone, implant-abutment junction, and prosthetic component using implant supported single crown in the platform switching concept. According to the research hypothesis, using a platform-switched implant lowers the stress concentration at the peri-implant bone contact and implant-abutment junction.

The null hypothesis was that platform switching would not influence stress distribution at the implant-abutment junction and peri-implant bone interface.

Materials And Methods

Study Design

This in vitro computational study employed three-dimensional finite element analysis (FEA) to evaluate the biomechanical effects of platform switching on stress distribution at the implant-abutment junction, peri-implant bone, and prosthetic components of implant-supported single crowns.

Three-Dimensional Model Construction

Three-dimensional models representing three different implant-abutment configurations were developed and positioned in the mandibular first molar region. All implant models were assumed to be perfectly osseo-integrated. The following configurations were evaluated: Regular Platform (RP) Group: A 4.3-mm-diameter prosthetic platform that is attached to a 4.3-mm-diameter implant. Platform-Switched (PS) Group: A 4.3-mm diameter abutment connected to a 5.0-mm diameter implant with a prosthetic platform diameter of 5.0 mm. Wide Platform (WP) Group: A prosthetic platform with a diameter of 5.0 mm and an abutment with a diameter of 5.0 mm attached to a 5.0 mm implant. All implants had a length of 10 mm (Figure 1).

Geometric Parameters and Material Properties

The three-dimensional models were created using SolidWorks software (Dassault Systèmes, Waltham, MA, USA). The implant models were positioned within a bone block comprising cortical and trabecular bone, both of which were assumed to be homogeneous, isotropic, and linearly elastic. The implant had a thread pitch of 0.71 mm, thread height of 9.02 mm, and an overall length of 10.6 mm. Following implant placement and the assumption of complete osseointegration, a cement-retained single crown was designed for each model. The prosthetic crown had a height of 7.5 mm and a mesiodistal width of 11 mm. The material properties assigned to each component of the model are presented in (Table 1.)

Finite Element Mesh Generation

The three-dimensional models were imported into ANSYS software (ANSYS Inc., Canonsburg, PA, USA) for finite element analysis. Tetrahedral elements were used to generate the finite element mesh. The RP model comprised 23,472 nodes and 115,937 elements. The PS model consisted of 31,143 nodes and 163,119 elements, whereas the WP model contained 23,036 nodes and 113,575 elements.

Boundary Conditions and Loading Conditions

The implant-bone interface was assumed to be perfectly bonded, representing complete osseointegration. Loading conditions were simulated by applying a static force of 100 N to the buccal cusp of the prosthetic crown under two conditions: Axial loading along the long axis of the implant Lingual-to-buccal oblique stress at a 30° angle to the implant's longitudinal axis The loading conditions are illustrated in (Figure 2.)

Outcome Measures

The primary outcome measure was the distribution of von Mises stress within the peri-implant bone, implant-abutment junction, retention screw, and prosthetic crown. Maximum principal (tensile) stress and minimum principal (compressive) stress values within the cortical and trabecular bone were also evaluated. Stress distributions under axial and oblique loading conditions were analyzed and compared among the RP, PS, and WP models.

Results

Stress Distribution In The Models

It is possible to compare the stress distribution in the various structures of the three models (peri implant bone tissue, implant, prosthetic screw, and prosthesis) for both loading scenarios by displaying the processed data from finite element software in stress maps with a colour scale (Figure 3).

In RP & WP groups, most of the stresses were located on the implant-abutment connections and in peri- implant bone on which loads were applied, whereas in the PS group these stress was lowered. The distribution of stress was found to be less severe and concentrated in the PS and WP groups than in the RP group. Oblique loads produced greater strains among the models than axial loads, despite the fact that the pattern of stress distribution was comparable for both loading scenarios. For bone, implant, retention screw, and abutment, the PS group showed lower stress values than the RP & WP group (Figure 4). The maximum and minimum primary stresses are also included to enable quantitative comparison of stress concentrations across the model structures. Maximum tensile stress and maximum compressive stress were determined by taking the positive values of the maximum principal stress and the negative values of the minimum principal stress, respectively (Figure 5).

Stress Distribution In Peri- Implant Bone Tissues

Cortical bone showed greater stress concentration than trabecular bone in all models under both loading conditions when the peri-implant bone tissues were examined. PS was found to significantly lower von Misses stress values (22.07%–34.11%) for axial and oblique loads, respectively (figure 6). Compressive stresses were higher than tensile stresses in all the models. However, in PS group both maximum principal (tensile) stress and minimum principal (compressive) stress was reduced. Compressive stress was 15.78 % axially and 35.84% obliquely and tensile stress was 43.15% for axial load and 20.51% for oblique load (table 2 and 3) in peri- implant bone (figure 7).

Distribution of Stress In Implant Along With Prosthetic Connection

In the PS & WP group, the abutment and prosthesis had greater stress values than the bone tissues, implant, and retention screw; in contrast, the RP group had higher stress values on the implant than on the bone tissues, retention screw, abutment, and prosthesis. The Maximum stress were seen on the outer edge of abutment all the three models but least amount of stress was observed in PS group which is 14.04 MPa , 27.32 in RP and 24.42 MPa in WP group (figure 8). During oblique loading maximum von misses was observed in the implant-abutment connection, stresses were less as compared to force induced by axial load, in PS model 14.46 mpa (figure 9).

For all models, the stress was focused at the implant's thread and neck on the side of loading along the abutment retention screw's contact interface (Figure 10). Maximum von mises stress was seen in first and second thread of implant in RP 30.61 MPa axial and 32.92 mpa oblique, however, these stresses were lowered in PS group 9.85mpa axial and 16.05 mpa oblique and in WP group 22.71 MPa axial and 28.48 mpa oblique.

When 100 N of axial force is applied on the prosthesis , maximum stress values were on the center of prosthesis in all the model but highest von mises stress was in WP (35.06 MPa), than in RP (32.65 MPa) ,and least amount of stress was observed in PS (14.05 MPa). It was also been observed that stresses was higher during oblique force as compared to axial force, maximum stress were seen in RP (53.5 MPa) as compared to WP (45.94 MPa) and least amount of stress was observed in PS (12.32 MPa) induced by oblique load (figure 11).

Discussion

The present three-dimensional finite element analysis evaluated the biomechanical effect of platform switching on stress distribution at the implant-abutment junction, peri-implant bone, and prosthetic components in implant-supported single crowns. The findings demonstrated that the platform-switched (PS) model exhibited lower von Mises stress values in the peri-implant bone, implant-abutment interface, abutment, retention screw, and prosthetic crown compared with the regular platform (RP) and wide platform (WP) models. In addition, oblique loading generated greater stress concentrations than axial loading in all configurations.

Conceptual Basis and Evidence from Previous Studies

Platform switching is based on the clinical finding that moving the implant-abutment junction (IAJ) horizontally away from the crestal bone may reduce crestal bone resorption [11]. The idea is to relocate the IAJ toward the implant's central axis by using an abutment that is smaller in diameter than the implant platform.

Two principal mechanisms have been proposed to explain the reduction in marginal bone loss associated with platform switching. From a biomechanical perspective, the inward repositioning of the IAJ redistributes stresses away from the cervical bone-implant interface, thereby reducing micro movements and stress concentrations in the adjacent bone [12]. From a biologic standpoint, platform switching moves the inevitable microgap away from the crestal bone, potentially minimizing the influence of inflammatory cell infiltrate on marginal bone resorption [14].

Ericsson et al. and Berglundh and Lindhe investigated localized inflammation in the peri-implant soft tissues surrounding the implant-abutment junction and identified an inflammatory connective tissue (ICT) zone around the IAJ [15,16]. This inflammatory infiltrate extends approximately 0.75 mm above and below the implant-abutment junction, while an additional zone of healthy connective tissue is required to establish an effective biologic seal [15-18]. Therefore, the inward repositioning of the IAJ through platform switching may reduce the influence of inflammatory infiltrate on the surrounding crestal bone [17,18].

Similarly, Hermann et al. reported that positioning the microgap coronally away from the alveolar crest was associated with reduced marginal bone loss, whereas apical placement of the microgap resulted in increased bone resorption [19,20].

Interpretation of the Present Findings

The present study demonstrated that oblique loading generated higher stress concentrations than axial loading across all implant-abutment configurations. Furthermore, cortical bone exhibited higher stress concentrations than trabecular bone under both loading conditions. The PS and WP models demonstrated lower stress values in the peri-implant bone than the RP model, with the PS group exhibiting the lowest stress values.

While the WP group showed equivalent stress levels of 17.90 MPa and 46.52 MPa, the PS group showed peri-implant bone stress values of 13.95 MPa under axial loading and 30.65 MPa under oblique loading. The PS model also showed the lowest stress values for the prosthetic crown and retention screw. The retention screw showed a maximum principal stress of 3.2 MPa, a minimum principal stress of −1.6 MPa, and a von Mises stress of 3.3 MPa. In a similar vein, the prosthetic crown showed minimum principal stress of −19.79 MPa, maximum principal stress of −4.39 MPa, and von Mises stress of 14.6 MPa.

These findings support the study hypothesis that platform switching reduces stress concentration at the implant-abutment junction and peri-implant bone interface.

Mechanical Explanation of the Findings

The favourable biomechanical performance of platform-switched implants observed in the present study may be attributed to the inward displacement of the implant-abutment junction, which relocates the stress concentration zone toward the center of the implant complex and away from the crestal bone.

Maeda et al. demonstrated through finite element analysis that platform switching decreases shear stress at the bone-implant interface while increasing stress concentration within the abutment and abutment screw [13]. Similarly, Pellizzer et al. reported that platform-switched models exhibited a more centralized stress distribution toward the implant apex under axial loading conditions [24]. The present findings are consistent with those of Gurgel-Juarez et al., who reported lower stress concentrations around external hexagonal platform-switched implants than around internal hexagonal implants [21]. The larger implant diameter associated with platform-switched designs may increase the bone-implant contact area and contribute to improved stress distribution. Ding et al. suggested that wider implants engage a greater volume of surrounding bone, thereby improving load transfer and reducing stress concentrations in the peri-implant region [22,23].

The higher stress concentrations observed under oblique loading are consistent with previous mathematical and finite element analyses demonstrating that oblique forces generate lateral force components and bending moments, resulting in increased stress concentrations at the implant-abutment interface and surrounding bone [8]. Maeda et al. further reported that stress concentrations in platform-switched implants are primarily located at the center of the implant-abutment connection, specifically around the implant screw level [13].

Clinical Significance

The reduced stress concentrations observed in the platform-switched model suggest that this design may contribute to improved preservation of peri-implant crestal bone and enhanced biomechanical stability of implant-supported restorations.

Atieh et al. reported that platform-switched implants exhibited significantly less marginal bone loss than non-platform-switched implants, while maintaining comparable implant survival rates [25,26]. They further demonstrated that greater differences between implant and abutment diameters were associated with improved marginal bone preservation [25,26].

Canullo et al. observed that increasing the implant-abutment mismatch resulted in superior preservation of peri-implant marginal bone levels [27]. The clinical advantages of platform switching have been attributed to improved stress distribution, increased biologic width, enhanced soft tissue sealing, and greater separation of the inflammatory infiltrate from the crestal bone [27].

Therefore, platform switching may be particularly beneficial in esthetically demanding regions where maintenance of crestal bone and soft tissue architecture is essential.

Study Limitations

The constraints of finite element analysis should be taken into consideration when interpreting the study's results. It was assumed that the materials utilised in the models were

linearly elastic, homogenous, and isotropic. Static loading conditions were used, and complete osseointegration at the implant-bone contact was postulated.
Clinical variables such as variations in bone density, dynamic occlusal loading, parafunctional habits, implant positioning, and biologic responses of the peri-implant tissues were not considered. Therefore, the results may not fully replicate the complex clinical environment.

Future Research Recommendations
Future studies should incorporate patient-specific bone characteristics, anisotropic material properties, and dynamic loading conditions to improve the clinical relevance of finite element models. Long-term clinical and prospective studies are necessary to validate the biomechanical advantages of platform switching observed in computational analyses.

Conclusion
Within the limitations of this three-dimensional finite element analysis, platform-switched implants demonstrated lower stress concentrations in the peri-implant bone, implant-abutment junction, retention screw, and prosthetic components than regular platform and wide platform designs.
The platform-switched model exhibited lower von Mises, tensile, and compressive stress values under both axial and oblique loading conditions. Oblique loading generated higher stress concentrations than axial loading in all implant configurations, and cortical bone demonstrated greater stress concentrations than trabecular bone.
The inward repositioning of the implant-abutment junction associated with platform switching appears to improve stress distribution and may contribute to preservation of peri-implant crestal bone. Consequently, platform switching may be a beneficial treatment strategy, particularly in esthetically demanding regions where maintenance of hard and soft tissue architecture is critical.

References

1. Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg. 1981;10:387-416.
2. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria for success. Int J Oral Maxillofac Implants. 1986;1:11-25.
3. Hermann JS, Cochran DL, Nummikoski PV, Buser D. Crestal bone changes around titanium implants: A radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. J Periodontol. 1997;68:1117-1130.
4. Lazzara RJ, Porter SS. Platform switching: A new concept in implant dentistry for controlling postrestorative crestal bone levels. Int J Periodontics Restorative Dent. 2006;26:9-17.
5. Singh R, Singh SV, Arora V. Platform switching: A narrative review. Implant Dent. 2013;22:453-459.
6. Shetty M, Prasad DK, Sangeetha UN, Chetan H. Platform switching: A new era in implant dentistry. Int J Oral Implantol Clin Res. 2010;1:61-65.
7. Shirbhate AA, Byakod GN, Gupta SG, Muglikar SD. Concept of platform switching. Univ Res J Dent. 2016;6:20-24.
8. Tabata LF, Rocha EP, Barão VA, Assunção WG. Platform switching: Biomechanical evaluation using three-dimensional finite element analysis. Int J Oral Maxillofac Implants. 2011;26:482-491.
9. Serrano-Sánchez P, Calvo-Guirado JL, Manzanera-Pastor E, Lorrio-Castro C, Bretones A, Pérez-Llanes JA, et al. The influence of platform switching in dental implants: A literature review. Med Oral Patol Oral Cir Bucal. 2011;16:e400-e405.
10. Rodríguez-Ciurana X, Vela-Nebot X, Rodado-Alonso C, Méndez-Blanco V, Segalà-Torres M. Biomechanical repercussions of bone resorption related to biologic width: A finite element analysis of three implant-abutment configurations. Int J Periodontics Restorative Dent. 2009;29:479-487.
11. Vigolo P, Givani A. Platform-switched restorations on wide-diameter implants: A 5-year clinical prospective study. Int J Oral Maxillofac Implants. 2009;24:103-109.
12. Gardner DM. Platform switching as a means to achieving implant esthetics. N Y State Dent J. 2005;71:34-37.
13. Maeda Y, Miura J, Taki I, Sogo M. Biomechanical analysis on platform switching: Is there any biomechanical rationale? Clin Oral Implants Res. 2007;18:581-584.
14. Becker J, Ferrari D, Herten M, Kirsch A, Schwarz F. Influence of platform switching on crestal bone changes at non-submerged titanium implants: A histomorphometrical study in dogs. J Clin Periodontol. 2007;34:1089-1096.
15. Fickl S, Zuhr O, Stein JM, Hürzeler MB. Peri-implant bone level around implants with platform-switched abutments. Int J Oral Maxillofac Implants. 2010;25:577-581.
16. Ericsson I, Persson LG, Berglundh T, Marinello CP, Lindhe J, Klinge B. Different types of inflammatory reactions in peri-implant soft tissues. J Clin Periodontol. 1995;22:255-261.
17. Wagenberg B, Froum SJ. A prospective study of 94 platform-switched implants observed from 1992 to 2006. Int J Periodontics Restorative Dent. 2010;30:9-17.
18. Chang CL, Chen CS, Yeung TC, Hsu ML. Biomechanical effect of platform switching in implant dentistry: A three-dimensional finite

element analysis. Int J Oral Maxillofac Implants. 2010;25:295-304.

19. Hermann F, Lerner H, Palti A. Factors influencing the preservation of the peri-implant marginal bone. Implant Dent. 2007;16:165-175.
20. Veis A, Tsirlis AT, Papadeli C, Marinis G, Zogakis A. Evaluation of peri-implant marginal bone loss using modified abutment connections at various crestal level placements. Int J Periodontics Restorative Dent. 2010;30:609-617.
21. Gurgel-Juarez NC, Rocha EP, Anchieta RB, de Almeida EO, Freitas AC Jr, de Sousa Gomes ÉA. Regular and platform switching bone stress analysis varying implant type. J Prosthodont. 2012;21:160-166.
22. Ding X, Zhu XH, Liao SH, Zhang XH, Chen H. Implant-bone interface stress distribution in immediately loaded implants of different diameters: A three-dimensional finite element analysis. J Prosthodont. 2009;18:393-402.
23. Pellizzer EP, de Carvalho PS, Verri FR, Falcón-Antenucci RM, Goiato MC, Noritomi PY. Photoelastic analysis of the influence of platform switching on stress distribution in implants. J Oral Implantol. 2010;36:419-424.
24. Pellizzer EP, Verri FR, Falcón-Antenucci RM, Goiato MC, de Souza Batista VE. Stress analysis in platform switching implants: A three-dimensional finite element study. J Oral Implantol. 2012;38:587-594.
25. Sevellela S, Guazzo R, Bressan E, Berengo M, Stellini E. Platform switching on wide-diameter external hex implants: A finite element analysis. J Clin Exp Dent. 2013;5:e77-e82.
26. Atieh MA, Ibrahim HM, Atieh AH. Platform switching for marginal bone preservation around dental implants: A systematic review and meta-analysis. J Periodontol. 2010;81:1350-1366.
27. Canullo L, Pellegrini G, Allievi C, Trombelli L, Annibali S, Dellavia C. Soft tissues around long-term platform switching implant restorations: A histologic human evaluation. Preliminary results. J Clin Periodontol. 2011;38:86-94.
28. Canullo L, Fedele GR, Iannello G, Jepsen S. Platform switching and marginal bone-level alterations: The results of a randomized-controlled trial. Clin Oral Implants Res. 2010;21:115-121.

List of Figures

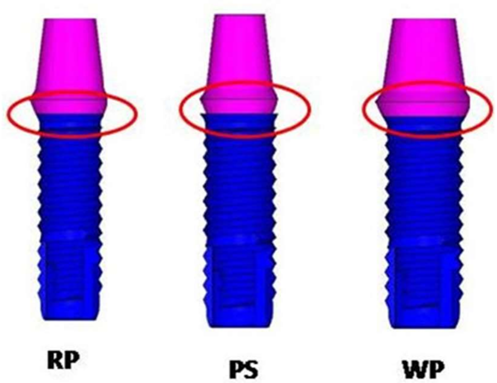

Fig.1: Three dimensional model of the RP,PS & WP implant and abutment connection

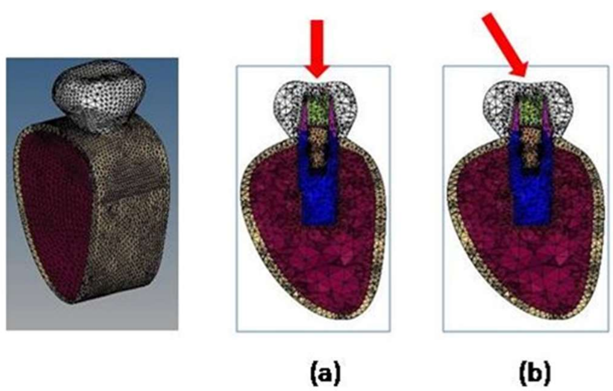

Fig.2: Frontal and oblique view of the finite element mesh of the PS model (31143 nodes and 163119 elements). (a) 100 N of axial load applied on the occlusal surface and (b) 100 N of oblique load applied on occlusal surface

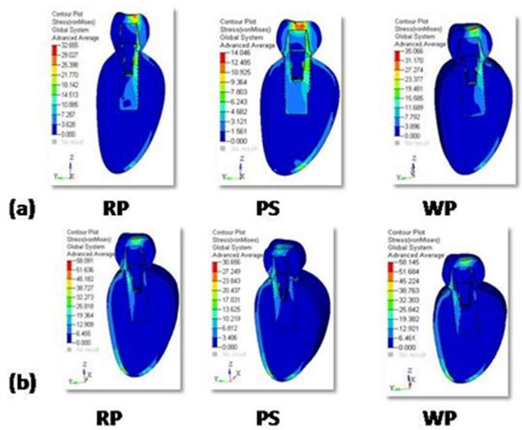

Fig.3: Von mises stress distribution for the RP, PS & WP models as a function of (a) axial and (b) oblique load

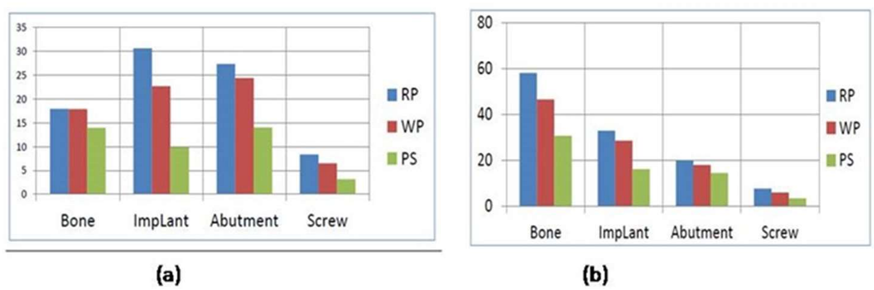

Fig.4: Von Mises stress values (in MPa) in bone tissue, implant, prosthetic screw, and prosthesis for the RP,PS, and WP models as a function of (a) axial and (b) oblique loads.

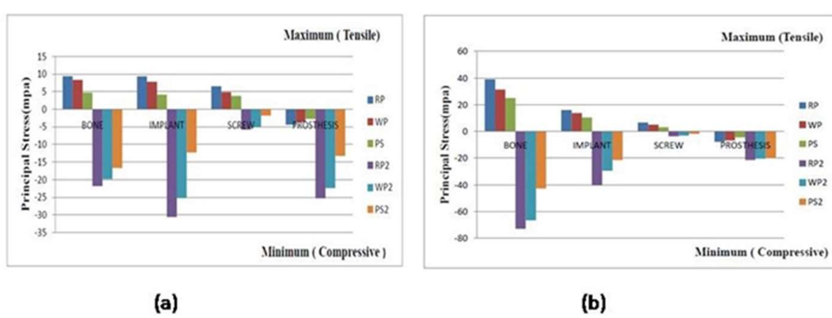

Fig.5: Maximum (tensile) and minimum (compressive) principle stress values (in MPa) in bone tissue, implant, screw, and prosthesis for the RP,PS, and WP models as a function of (a) axial and (b) oblique loads.

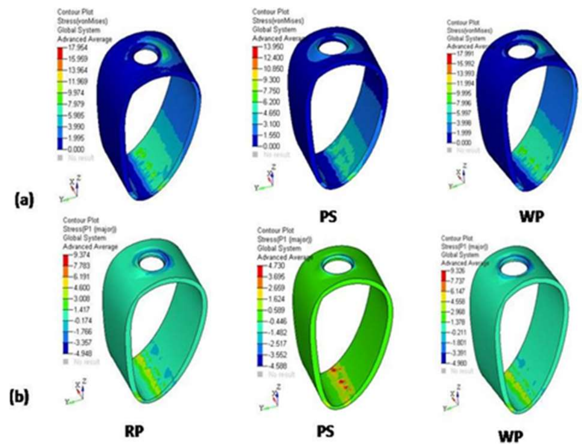

Fig.6: Von Mises, (a) maximum (tensile),and (b) minimum (compressive) principal stress values in the periimplant bone tissue for the RP,PS, and WP models induced by axial load

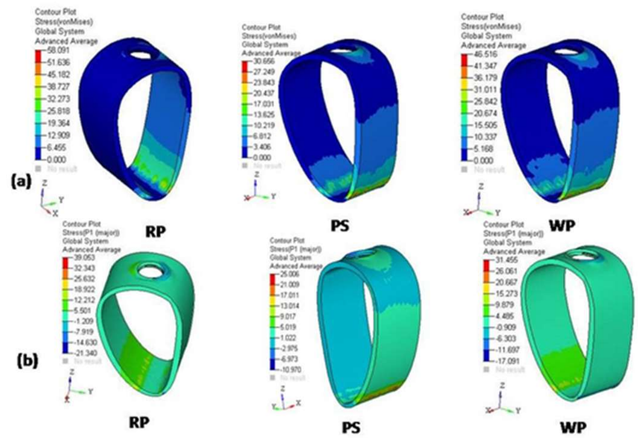

Fig.7: Von Mises, (a) maximum (tensile), and (b) minimum (compressive) principal stress values in the periimplant bone tissue for the RP, PS, and WP models induced by oblique load.

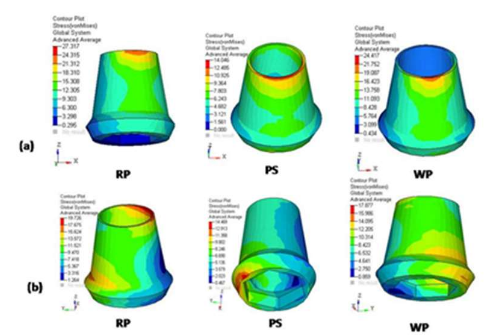

Fig.8: Von misses stress distribution at the abutment for RP,PS &WP models as a abutment function of (a) axial (b) oblique loads

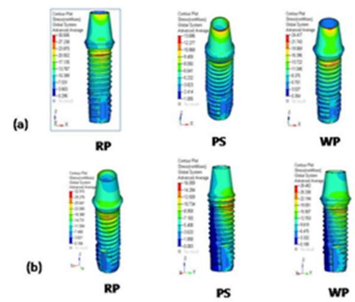

Fig.9: Von misses stress distribution at the abutment for RP,PS &WP models as a the implant and abutment (a) axial function of (a) axial (b) oblique loads

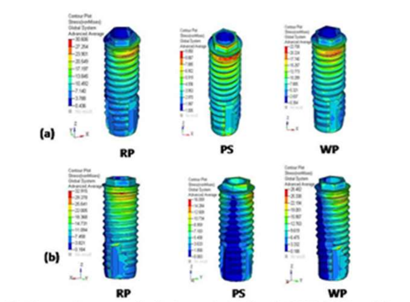

Fig.10: Von misses stress distribution at the stress distribution at the implant for RP,PS &WP models as a function of (a) axial (b) oblique loads

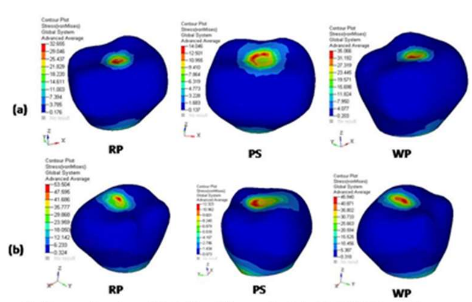

Fig.11: Von misses stress distribution at the implant for RP,PS &WP models as a function of (a) axial (b) oblique loads

Tables

TABLE 1- Properties of structure and materials used in the study

Material	Elastic modulus	Poisson's ratio
Cortical bone	1.34×10^4 Pa	0.30
Trabecular bone	1.37×10^3 Pa	0.31
Porcelain	68.9×10^3 Pa	0.28
Titanium	117×10^3 Pa	0.30
Co- cr alloy	218×10^3 Pa	0.33

TABLE 2- Effect of implant diameter and platform configuration on von mises, maximum and minimum principal stress concentrations (in Mpa) in the models under axial loading

Axial loading	Effect of implant diameter			Effect of platform switching		
Location/type of stress	RP	WP	%Decrease *	WP	PS	%Decrease **
Bone						
Von-Mises Stress	17.95	17.9	0.28	17.9	13.95	22.07
Max-Principal Stress	9.37	8.32	11.21	8.32	4.73	43.15
Min-Principal Stress	-21.82	-19.84	9.07	-19.84	-16.71	15.78
Implant						
Von-Mises Stress	30.61	22.71	25.81	22.71	9.85	56.63
Max-Principal Stress	9.34	7.79	16.60	7.79	4.13	46.98
Min-Principal Stress	-30.58	-25.25	17.43	-25.25	-12.26	51.45
Screw						
Von-Mises Stress	8.36	6.5	22.25	6.5	3.2	50.77
Max-Principal Stress	6.52	4.83	25.92	4.83	3.76	22.15
Min-Principal Stress	-5.77	-4.97	13.86	-4.97	-1.81	63.58
Abutment						
Von-Mises Stress	27.32	24.42	10.61	24.42	14.04	42.51
Max-Principal Stress	-4.39	-3.65	16.86	-3.65	-2.74	24.93
Min-Principal Stress	-25.29	-22.38	11.51	-22.38	-13.26	40.75

*Decrease in stress calculated as: (RP – WP)/RP × 100%.

**Decrease in stress calculated as: (WP – PS)/WP × 100%.

TABLE 3 - Effect of implant diameter and platform configuration on von mises, maximum and minimum principal stress concentrations (in Mpa) in the models under oblique loading

Oblique Loading	Effect of Implant Diameter			Effect of Platform Switching		
Location/type of stress	RP	WP	%Decrease*	WP	PS	%Decrease**
Bone						
Von-Mises Stress	58.09	46.52	19.92	46.52	30.65	34.11
Max-Principal Stress	39.05	31.45	19.46	31.45	25	20.51
Min-Principal Stress	-72.86	-66.52	8.70	-66.52	-42.68	35.84
Implant						
Von-Mises Stress	32.91	28.48	13.46	28.48	16.05	43.64
Max-Principal Stress	15.94	13.7	14.05	13.7	10.5	23.36
Min-Principal Stress	-40.36	-29.31	27.38	-29.31	-21.4	26.99
Screw						
Von-Mises Stress	7.65	5.94	22.35	5.94	3.33	43.94
Max-Principal Stress	6.74	4.94	26.71	4.94	3.21	35.02
Min-Principal Stress	-3.66	-3.12	14.75	-3.12	-1.66	46.79
Abutment						
Von-Mises Stress	19.73	17.87	9.43	17.87	14.46	19.08
Max-Principal Stress	-7.85	-6.82	13.12	-6.82	-4.39	35.63
Min-Principal Stress	-21.46	-20.27	5.55	-20.27	-19.79	2.37

*Decrease in stress calculated as: (RP – WP)/RP × 100%.
**Decrease in stress calculated as: (WP – PS)/WP × 100%.