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Comparative Evaluation of Stress Distribution of Dental Implants Restored with Conventional Cement Retained and Screw Retained Porcelain Fused Metal Crown Using A Three Dimensional Finite Element Analysis – An in Vitro Study

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Abstract

A three-dimensional finite element analysis was conducted to compare the stress distribution on the dental implants restored with cement and screw retained PFM crown. To conduct this study, a three- dimensional geometry of implant-prosthesis in the lower first premolar of mandible was generated from computerized tomography scans using SolidWorks software. Two models of dental implants with cement and screw retained PFM crown was made. Both the models were subjected under a vertical and oblique (45 degree) load of 100 N. Then stress and strain distribution in bone and implant under both the loading condition was analysed.

Dental implant restored with cement retained PFM crown transmitted more stress to the surrounding bone under both vertical and oblique loading. Prosthesis restored with screw retained PFM crown transmitted less stress to the implant under both vertical and oblique loading. Dental implant restored with cement retained PFM crown transmitted more strain to the surrounding bone under both vertical and oblique loading. Prosthesis restored with screw retained PFM crown transmitted less

strain to the implant under both vertical and oblique loading.

The outcome of this study suggests the better clinical implication of screw retained dental prosthesis over cement retained dental prosthesis.

Keywords: Cement Retained, Screw retained, FEA and Stress distribution.

Introduction

Replacing missing teeth with artificial prosthesis has a long history. Time to time several advancements has been added in the field of dentistry. One such advancement is dental implants. The use of dental implants in the rehabilitation of patients has become a well-established and accepted contemporary clinical method with predictable long term success[1].

The success of dental implants is based on the maintenance of the surrounding bone against stress. The load transfers of the peripheral supporting bone around the implant differ depending on the occlusal load direction, supporting tissue quality, implant specification, fixture surface, implant connection, and restoration-retaining type. There are two different methods of retaining a fixed dental implant-supported restoration such as screw retention and conventional cement retained[2,3].

Determining the retaining type, such as screw or cement retained, is an important step in definitive restoration. This is because the marginal bone stability, success rates and complication rates of implants can differ according to the retaining type of implant restoration[4].

Selecting the type of retention for implant prostheses is considered a clinically important decision. If continuous overloading is applied to peri-implant bone, bone resorption can occur, which could lead to implant failure[5,6] . Therefore, a biomechanical examination of the implant and surrounding bone is necessary to judge the success of the implant prosthesis by evaluating the dangers of marginal bone loss[7].

Insufficient mechanical stimuli, loading transferred to the crestal bone, microbial accumulation surrounding the implant and in the peri-implant tissues, are the potential causes of bone resorption. Aesthetics and mechanical conditions following prosthetic rehabilitation are directly related to the high success rate of dental implants[8]. Even though dental implants are very successful failure can occur shortening the lifespan of dental treatments, when implant-supported restorations are subjected to overload conditions[9].

A number of factors pertaining to implant-supported prosthesis design are presented in the literature. During the prosthesis manufacturing process, one of these factors is the crown retention system, which can be didactically classified as either screw-retained or cement-retained[10]. There is disagreement about the best kind of prosthesis retention for the long-term success of implant therapy[11].

Dental professionals are very concerned about the distribution of stress at the interface between dental implants and cortical bone. There have been attempts to reduce cortical bone stress and produce a stress pattern resembling that of natural teeth. Because bone is anisotropic and has unique properties that vary from subject to site, its mechanical behaviour is complicated[12].

One numerical method for analyzing and simulating physical phenomena is the finite element (FE) method. It is frequently used in product design to optimize components and lessen the need for physical prototypes and experiments, resulting in better products that are produced more quickly and affordably[13]. In order to comprehend and measure a variety of physical phenomena, such as fluid and structural behaviour, mechanical stress, thermal transport, wave propagation, and biological cell growth, the FE method depends on mathematical models. Due to technological advancements, the FE method has grown in utility and has excellent growth potential going forward. The global simulation and analysis software market was valued at USD 18.25 billion in 2022 and is expected to expand at a compound annual growth rate of 14%[14].

Functional requirements (such as osseointegration) and aesthetic requirements—which are inextricably linked to the soft-tissue architecture surrounding the implant—must be used to evaluate the long-term viability of dental implants. Although the current corpus of research makes it evident that the stability of peri-implant bone can be impacted by the condition of the soft tissues surrounding the implant, it is unclear if the soft tissues are affected differently by various implant restoration types[15].

The present study was aimed to compare the analysis of stress distribution on dental implants restored with conventional cement retained and screw retained porcelain fused metal crown using a three dimensional finite element analysis.

Materials And Method

The present in vitro study was conducted to assess the stress distribution in dental implants restored with cement retained and screw retained PFM crown by means of by 3-D finite element analysis.

CT scan of a section of type three edentulous posterior mandible having premolar area is done. The obtained Dicom file is converted to STL file with slicer software. This STL file is sent to a graphic preprocessing software ANSYS 2023 via Space Claim software. This software generates the finite element geometry (nodes and element). Two solid 3-D models are generated by Solid Work software.

Two straight implants placed in first mandibular premolar region bilaterally. Two models of implant cement and screw retained PFM crown were generated. All the components were individually modelled with having different physical properties (Table 1,2,3,4) and assembled (Fig.1) (Fig.2). The entire assembly was then exported for analysis with ANSYS Workbench.

The axial load of 100 N and oblique load of 100N at 45 degree of angle was applied individually on both the models one by one at the direction of buccal tip of buccal cusp of premolar. After application of force the magnitude were analysed by ANSYS Workbench a 3-D finite element analysis program. An assessment of the stress on the bone, implant and strain on the bone was performed. A color scale with stress and strain values was used to evaluate quantitatively the stress and strain distribution in the bone and implant. The scale for stress runs from lowest (blue) to the highest stress values (red). Red indicates areas with highest stress, and blue indicates areas with the lowest stress.

Result

The maximum von Mises stress of bone in dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N was present in oblique loading cement retained (Fig. 3,4,11,12) (Table 5) (Graph 1).

The maximum von Mises stress in dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N was present in oblique loading cement retained (Fig. 5,6,13,14) (Table 6) (Graph 2).

The maximum strain in bone surrounding dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N was present in oblique loading cement retained (Fig. 7,8,15,16) (Table 7) (Graph 3).

The maximum strain in dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N was present in oblique loading cement retained (Fig.9,10,17,18) (Table 8) (Graph 4).

Table 1: Mechanical properties – Bone

Material	Young's Modulus (GPa)	Poisson's coefficient	Density (kg/m^3)
Cortical bone	13	0.30	1180
Trabecular bone	1.3	0.30	500

Table 2: Material properties - PFM crown

Material	Component	Young's Modulus (GPa)	Poisson's coefficient
Cr-Co alloy	Crown structure	218	0.33
Feldspathic ceramic	Crown veneering	65	0.25

Table 3: Dimensional specification - Implant

Material	Ti-6Al-4V alloy
Macroscopic Design	Threaded
Length	11.5 mm
Diameter	4.2 mm

Table 4: Dimensional specification - Crown

Height	8.5 mm
Width	7 mm
Thickness	1.5 mm (0.5mm – Alloy) (1mm – ceramic coating)

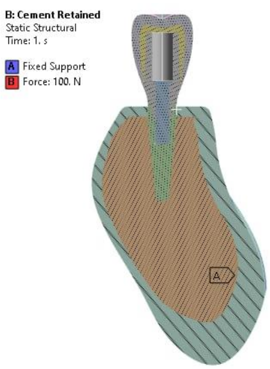


Figure 1: Model of dental implant restored with cement retained crown

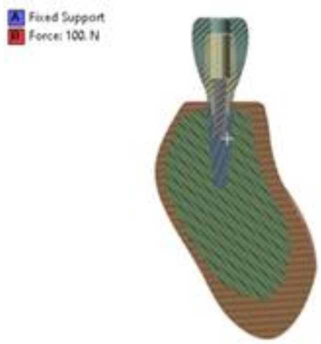
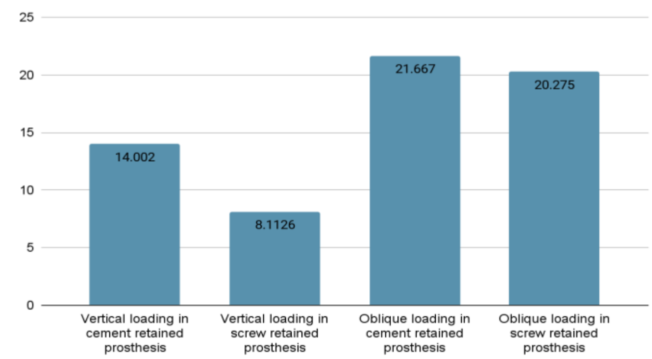


Figure 2: Model of dental implant restored with screw retained crown

Table 5: Comparison of von Mises stress of bone in dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N.

Location	Stress in bone (Mpa)
Vertical loading in cement retained prosthesis	14.002

Vertical loading in screw retained prosthesis	8.1126
Oblique loading in cement retained prosthesis	21.667
Oblique loading in screw retained prosthesis	20.275



Graph 1: von Mises stress of bone surrounding dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N.

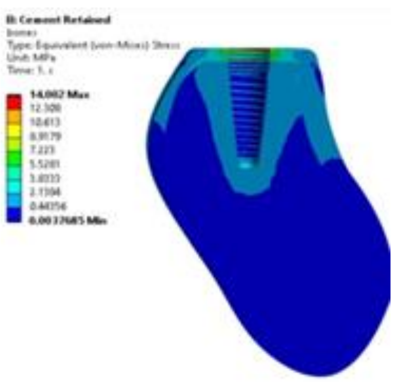


Figure 3: Maximum von Mises Stress in bone of cement PFM crown under vertical loading of 100 N.

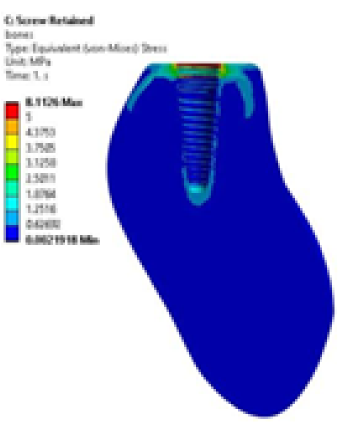


Figure 4: Maximum von Mises Stress in bone of SR retained PFM crown under vertical loading of 100 N.

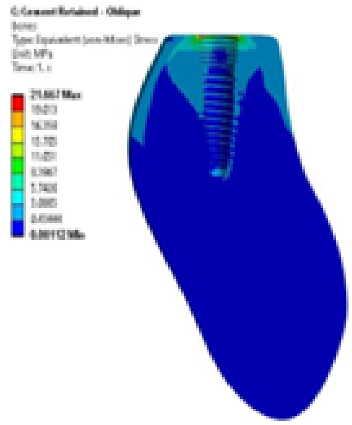


Figure 5: Maximum von Mises Stress in bone of cement PFM crown under oblique loading of 100N

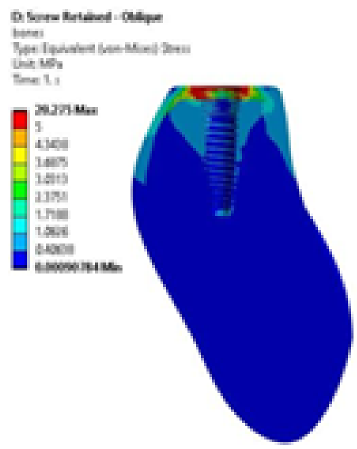
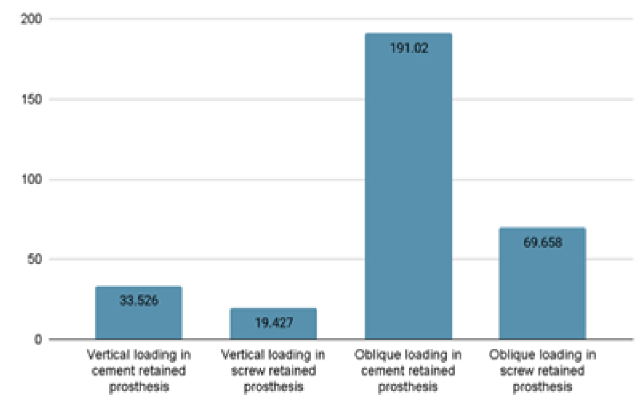


Figure 6: Maximum von Mises Stress in bone of screw PFM crown under oblique loading of 100 N

Table 6: Comparison of von Mises stress of dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N.

Location	Stress in Implant (Mpa)
Vertical loading in cement retained prosthesis	33.526
Vertical loading in screw retained prosthesis	19.427
Oblique loading in cement retained prosthesis	191.02
Oblique loading in screw retained prosthesis	69.658



Graph 2: von Mises stress in dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N.

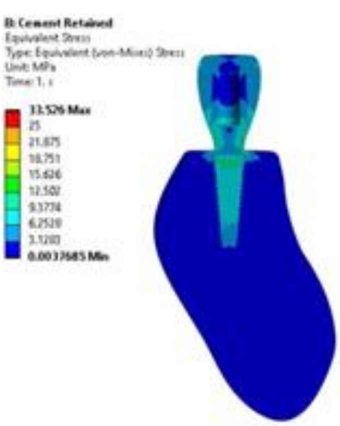


Figure 7: Maximum von Mises Stress in implant of cement

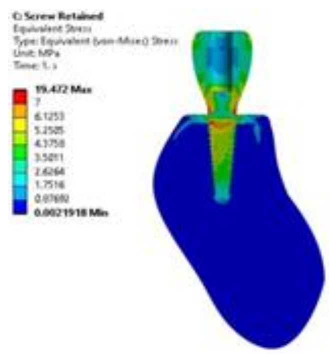


Figure 8: Maximum von Mises Stress in bone of SR retained PFM crown under vertical loading of 100 N.

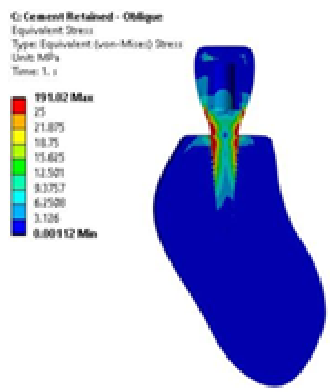


Figure 9: Maximum von Mises Stress in bone of cement retained PFM crown under oblique loading of 100 N

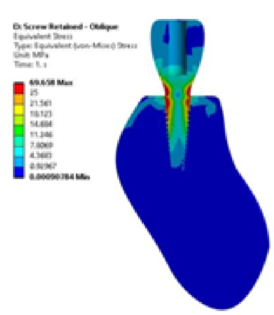
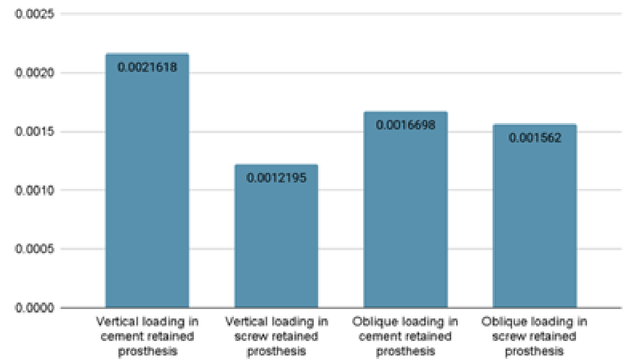


Figure 10: Maximum von Mises Stress in bone of screw retained PFM crown under oblique loading of 100 N

Table 7: Comparison of strain of bone in dental implant restored with cement and screw retained PFM crown in vertical and oblique loading of 100N.

Location	Strain in surrounding bone
Vertical loading in cement retained prosthesis	0.0021618
Vertical loading in screw retained prosthesis	0.0012195
Oblique loading in cement retained prosthesis	0.0016698
Oblique loading in screw retained prosthesis	0.001562



Graph 3: Strain in surrounding bone of implants restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N.

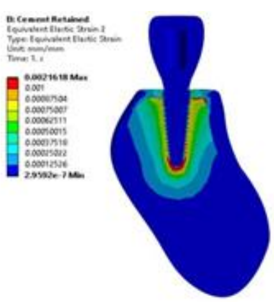


Figure 11: Maximum strain in bone surrounding implant of cement retained PFM crown under vertical loading of 100 N.

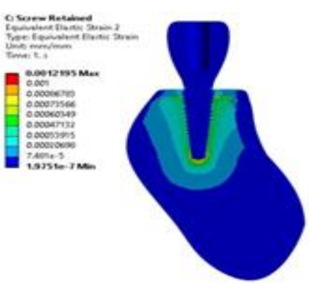


Figure 12: Maximum strain in bone surrounding implant of screw retained PFM crown under vertical loading of 100 N.

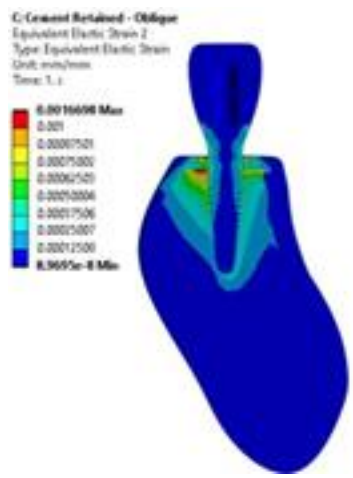


Figure 13: Maximum strain in bone surrounding implant of cement retained PFM crown under oblique loading of 100 N.

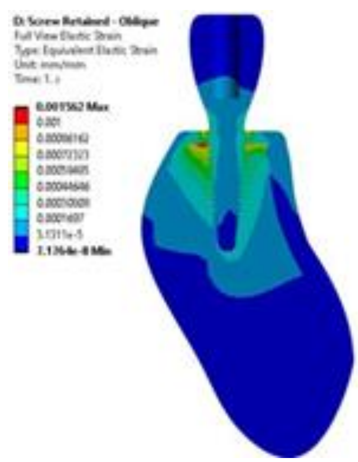
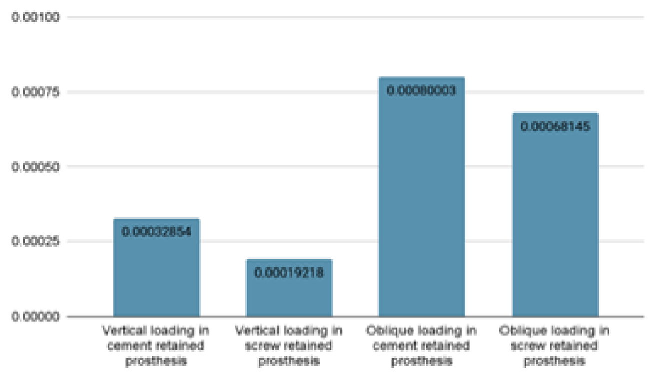


Figure 14: Maximum strain in bone surrounding implant of screw retained PFM crown under oblique loading of 100 N.

Table 8: Comparison of strain in dental implant restored with cement and screw retained PFM crown in vertical and oblique loading of 100N.

Location	Strain in implant
Vertical loading in cement retained prosthesis	0.00032854
Vertical loading in screw retained prosthesis	0.00019218
Oblique loading in cement retained prosthesis	0.00080003
Oblique loading in screw retained prosthesis	0.00068145



Graph 4: Strain in dental implant restored with cement and screw retained PFM crown in vertical loading of 100N and oblique loading of 100N.

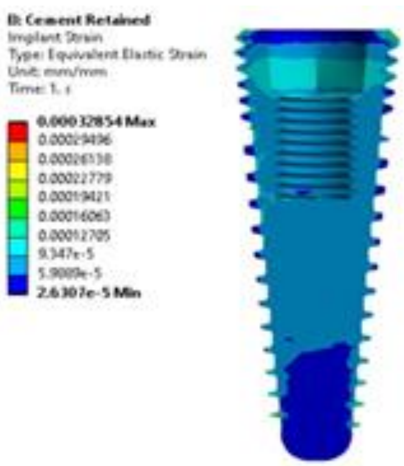


Figure 15: Equivalent elastic strain in implant of cement retained PFM crown under vertical loading of 100N

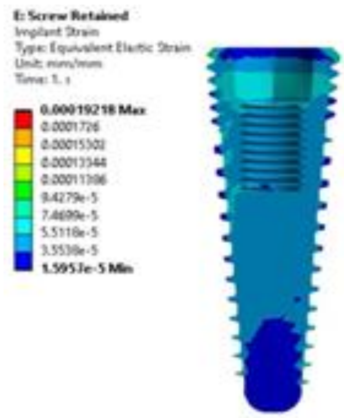


Figure 16: Equivalent elastic strain in implant of cement retained PFM crown under vertical loading of 100N

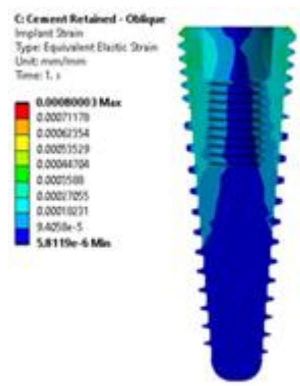


Figure 17: Equivalent elastic strain in implant of cement retained PFM crown under oblique loading of 100N

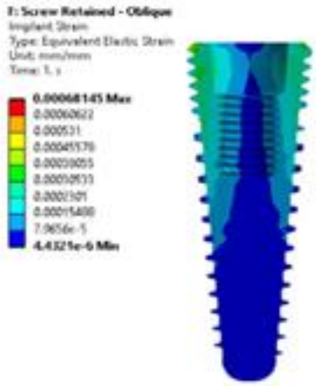


Figure 18: Equivalent elastic strain in implant of screw retained PFM crown under oblique loading of 100N

Discussion

A comparison of the biomechanical behaviour of screw-retained and cement-retained prostheses with respect to the creation of stress and strain on implant and bone has been studied. In this finite element study the stress, strain distribution on cement, screw retained dental implants and the surrounding bone was evaluated. Two models were made. Each model was loaded with vertical and oblique load of 100N (oblique load at an angle of 45 degree).

Stress analysis in bone

In vertical loading cement retained prosthesis maximum von Mises stress is 14.002Mpa while in screw retained prosthesis maximum von Mises stress is 8.1126Mpa. In oblique loading cement retained prosthesis maximum von Mises stress is 21.667Mpa while in screw retained prosthesis is 20.275Mpa. Stress is found to be more in oblique loading than vertical loading. In both the cases stress is found to be more in cement retained prosthesis rather than in the screw retained prosthesis. The distribution of the stress pattern in the cement retained and screw retained PFM crown is around the neck of the implant. Similarly Jae Hyun Lee et al[16] obtained similar result in his study. The otcome of this study is consistent with the results of Silva G C et al[17] study.

Stress analysis in implant

In vertical loading cement retained PFM crown maximum von Mises stress is 33.526Mpa while in screw retained PFM crown is 19.427Mpa. In oblique loading cement retained PFM crown has maximum von Mises stress is 191.02Mpa while in screw retained PFM crown is 69.658Mpa. In both the cases stress is found to be more in cement retained prosthesis rather than in the screw retained prosthesis. The distribution pattern of the stress is such that the maximum stress concentration was around the first and second thread of the implant in both the models. In the study done by Jae Hyun Lee et al[16] similar result is obtained. The maximum von Mises stress values in the implant of the screw-retained crown is less than that of the cement-retained crown. Eduardo P et al[18] found the stress distribution to be higher in the implants with screw retained prosthesis than the cement retained prosthesis. Marco C et al[19] found that screw retained prosthesis shows more concentration of stress than the cement retained.

Strain analysis in bone:

In vertical loading cement retained prosthesis maximum strain is 0.0021618 while in screw retained prosthesis is 0.0012195. In oblique loading cement retained prosthesis maximum von Mises stress is 0.0016698 while in screw retained prosthesis is 0.001562. In both the cases stress is found to be more in cement retained prosthesis rather than in the screw retained prosthesis. The distribution pattern in the cement retained crown under vertical loading is even all around the implant with the maximum strain found to be at the bone around the apical region of implant and around the bone of first thread of implant. In the screw retained crown under vertical loa the maximum strain was found to be in the bone surrounding the base region of implant. Under oblique load in both the cement and screw retained models the distribution of the strain was found to be more in the cervical region of implant. Jae-Hyun Lee et al[16] study showed cement-retained restoration model had greater maximum strain values in the supporting bone under both loading situations than the screw-retained model.

Strain analysis in implant

The maximum strain in the implant under vertical loading of 100 N was observed in dental implants restored with cement retained PFM crown. The maximum strain in cement retained crown is 0.00032854 while in screw retained crown is 0.00019218.

The maximum strain in the implant under oblique loading of 100 N was observed in dental implants restored with cement retained PFM crown. The maximum strain in cement retained crown is0.00080003 while in screw retained crown is 0.00068145.

Aqsa shaukat et al[20] observed the strain value lower in screw retained prosthesis than the cement retained which is opposite to the result of this study. The study done by Nancy et al[21] found the strain value higher in cement retained which is similar to the result as observed in this study.

Conclusion

A three-dimensional finite element analysis was conducted to compare the stress distribution on the dental implants restored with cement and screw retained PFM crown. Within the limitations of this study, the following conclusions were drawn:

Dental implant restored with cement retained PFM crown transmitted more stress to the surrounding bone under both vertical and oblique loading. Prosthesis restored with screw retained PFM crown transmitted less stress to the implant under both vertical and oblique loading. Dental implant restored with cement retained PFM crown transmitted more strain to the surrounding bone under both vertical and oblique loading. Prosthesis restored with screw retained PFM crown transmitted less strain to the implant under both vertical and oblique loading.

The outcome of this study suggests the better clinical implication of screw retained dental prosthesis over cement retained dental prosthesis.

References

1. Nissan J, Narobi D. Long term outcome of cemented versus screw retained implant-supported partial restoration. Int J Oral Maxillofac Implants.2011; 26:1102-1107.
2. Kim, JJ, Lee JH, Kim J.C Lee, J.B, Yeo. Biological responses to the transitional area of dental implants: Material- and structure-dependent responses of peri-implant tissue to abutments. Materials (Basel). 2019;13(1):72.
3. Mahajan T; Saini S. Combination implant crown: A cement and screw retained restoration. OCAI.2014;7(1):44-45.
4. Lee, J.H, Kim, J.C,Kim, H.Y,Yeo, I.L. Influence of connections and surfaces of dental implants on marginal bone loss: A retrospective study over 7 to 19 years. Int. J. Oral Maxillofac. Implant. 2020; 35:1195–1202.
5. Jankar A ,Kamble S. Screw vs. cement retained prostheses: a literature review. International journal of scientific research. 2020 ;9(10):2277 – 8179.
6. Pierrisnard, L, Hure, G,Barquins, M,Chappard, D. Two dental implants designed for immediate loading: A finite element analysis. Int. J. Oral Maxillofac. Implant. 2002; 17:353–362.
7. Anitua, E,Orive, G. Finite element analysis of the influence of the offset placement of an implant-supported prosthesis on bone stress distribution. J. Biomed. Mater. Res. B Appl. Biomater. 2009; 89:275–281.

8. Kim YT, Lim GH, Lee JH, Jeong SN. Marginal bone level changes in association with different vertical implant positions: A 3-year retro spective study. J Periodontal Implant Sci. 2017;47(4):231–239.
9. Raikar S, P. Talukdar, S. Kumari, S. Panda, V. Oommen, A. Prasad, Factors affecting the survival rate of dental implants: a retrospective study, J Int Soc Prev Community Dent. 2017;7(6):351-355.
10. Tribst JPM, A.M.O. Dal Piva, A.L.S. Borges, L.C. Anami, C.J. Kleverlaan, M.A. Bottino, Survival probability, Weibull characteristics, stress distribution, and fractographic analysis of polymer-infiltrated ceramic network restorations cemented on a chairside titanium base: an in vitro and silico study, MDPI. 2020;13(8):1-19,
11. Hebel KS, R.C. Gajjar, Cement-retained versus screw-retained implant restorations: achieving optimal occlusion and esthetics in implant dentistry, J Prosthet Dent.1997;77: 28–35.
12. Silva GC , T.M. Cornacchia, C.S. de Magalh˜aes, A.C. Bueno, A.N. Moreira, Biomechanical evaluation of screw- and cement-retained implant-supported prostheses: a nonlinear finite element analysis, J Prosthet Dent.2014;112:1479–1488.
13. Cristina F,V Francesco.Finite element analysis in implant dentistry: State of the art and future directions .Dental Materials.2023;39(6):539–556.
14. E. Stein (Ed.), The History of Theoretical, Material and Computational Mechanics - Mathematics Meets Mechanics and Engineering. Lecture Notes in Applied Mathematics and Mechanics, Springer 2014;399-442.
15. Mishra M, Ozawa S, Masuda T, Yoshioka F, Tanaka Y. Finite element study on the effect of abutment length and material on implant bone interface against dynamic loading. J Adv Prosthodont. 2011;3(3):140-144.
16. Lee J, H Jang, H, Y. Finite Element Analysis of Dental Implants with Zirconia Crown Restorations: Conventional Cement-Retained vs. Cementless Screw-Retained. Materials(Basel).2019;14(10):1-10.
17. Silva CG. Effects of Screw- and Cement-Retained Implant-Supported Prostheses on Bone: A Nonlinear 3-D Finite Element Analysis. Implantdent. 2015;24(4):464-71.
18. Torrado E, Ercoli C, Al Mardini M, Graser GN, Tallents RH, Cordaro L. A comparison of the porcelain fracture resistance of screw-retained and cement- retained implant-supported metal-ceramic crowns. J Prosthet Dent .2004;91:532-537.
19. Cicciu, M. FEM evaluation of cemented-retained versus screw-retained dental implant single-tooth crown prosthesis. Int J Clin Exp Med. 2014;7(4):817-825.
20. Shaukat A, Zehra N. Implant biomechanics relating to the dental implant and prosthesis design: In-vitro strain gauge analysis and finite element analysis. AIP Advances.2024;14(4): 045134-10.
21. C L Nancy,Y Burak. Three-Dimensional Image Correlation Analyses for Strains Generated by Cement and Screw-Retained Implant Prostheses. Clinical Implant Dentistry and Related Research.2011;15(2):1-12.