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Comparative evaluation of stress distribution between the various combinations of screw-retained and cement-retained implant frameworks with different internal connections by 3D Finite Element Analysis -an Invitro study

Arya K Nair, Nitesh Rai, Ponnanna A.A., Ranganatha Rao K Jingade , Muralidhar G , Roopa Patil

Department Of Prosthodontics, Krishnadevaraya College of Dental Sciences and Hospital, Bengaluru

Correspondence:
Dr. Nitesh Rai, Professor, Department of Prosthodontics, Krishnadevaraya College of Dental Sciences, Bengaluru 562157, Karnataka, India.

Email Id: serviceheb@gmail.com

ABSTRACT

Purpose:
To evaluate and compare the stress distribution on a mandibular 5-unit implant-supported fixed dental prosthesis (ISFDP) with either an internal hexagonal or internal conical hexagonal implant-abutment connection (IAC), considering prosthesis configurations of screw-retained (SRP), cement-retained (CRP), or a combination of both, using three-dimensional finite element analysis (3D FEA).

Methodology: An edentulous mandibular specimen was scanned to create a computerized image using cone beam computed tomography (CBCT). The data was converted to Stereo Lithography (STL) format, transformed into x, y, and z coordinates, and processed into three-dimensional solid geometry.

Eight models with 1 mm cortical bone and cancellous bone (D2 density) were created. Four models used implants with internal hex connections (4.2 x 10 mm), and
four used internal conical hex connections (4.3 x 10 mm), positioned at the mandibular canine, second premolar, and second molar regions.

Each model was loaded with a 5-unit Porcelain Fused Metal (PFM) implant prosthesis, featuring different implant-abutment assemblies:

The geometrical model of 8 groups of 5-unit implant prostheses with 3 implants having different implant-abutment assemblies namely ‘1’, ‘2’, and ‘3’ was designed.

- Model A: a 5-unit implant having an internal hex connector with all the units 1,2 and 3 being screw-retained
- Model B: a 5-unit implant having an internal hex connector with all the units 1,2 and 3 being cement-retained
- Model C: a 5-unit implant having an internal hex connector with units 1 and 3 being screw-retained and 2 being cement-retained
- Model D: a 5-unit implant having an internal hex connector with units 1 and 3 being cement-retained and 2 being screw-retained
- Model A': a 5-unit implant having an internal conical hexagon connector with all the units 1,2 and 3 being screw-retained

- Model B': a 5-unit implant having an internal conical hexagon connector with all the units 1,2 and 3 being cement-retained
- Model C': a 5-unit implant having an internal conical hexagon connector with units 1 and 3 being screw-retained and 2 being cement-retained
- Model D': a 5-unit implant having an internal conical hexagon connector with units 1 and 3 being cement-retained and 2 being screw-retained

A static load of 100 N to replicate occlusal loading, aligns with methodologies employed in previous research with 100 N applied axially on the buccal cusp of each crown to evaluate.

Results: The study investigated the stress distribution in dental prostheses using internal hexagonal and internal conical hex connections, comparing screw-retained and cement-retained configurations under a load of 100N. The analysis focused on Von Mises stress at various interfaces: overall stress, cortical implant interface, and abutment-implant interface.

Conclusion: The study evaluated the impact of different abutment connections and retention methods on stress distribution in mandibular 5-unit implant-supported prostheses using finite element analysis, focusing on splinted screw-retained and cement-retained prostheses. Key findings are as follows:

1. Stress Distribution:
    - Screw-Retained Prostheses: Consistently showed lower stress levels at critical interfaces (cortical bone-implant, cancellous bone-implant, and abutment implant) compared to cement-retained prostheses.
    - Cement-Retained Prostheses: Exhibited higher stress concentrations, indicating less effective stress distribution.
2. Comparison of Internal Connections:
    - Internal Hexagonal Connections: Models with these connections had higher stress levels compared to internal conical hex connections.
    - Internal Conical Hex Connections: Demonstrated better overall stress distribution, particularly when all abutments were screw-retained.
3. Mixed Retention Configurations:
    - Models combining screw and cement retention showed intermediate stress levels. Configurations with more screw-retained abutments performed better in terms of stress distribution than those with more cement-retained abutments.

Further, in-vivo studies need to be performed to evaluate the outcome of treatment.

Keywords:ISFDP (Implant-supported fixed dental prosthesis), Screw Retained Prosthesis (SRP), Cement Retained Prosthesis (CRP), Internal hexagonal connection, Internal conical hexagonal connection.

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