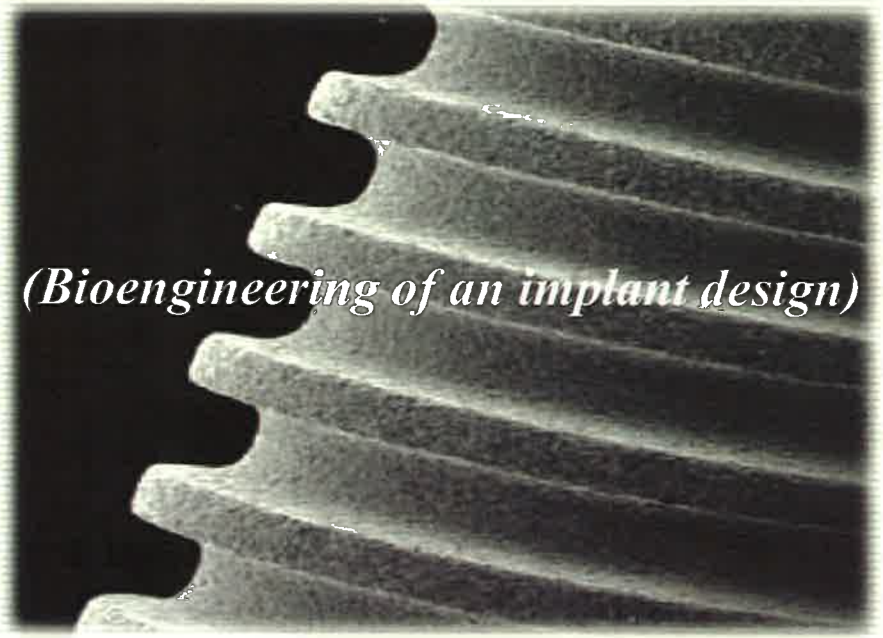
In the Name of God

Effect of Different Designs on Stress Distribution of Dental Implants using Finite Element Method



Amirkabir
University of Technology

دانشگاه علوم پزشکی و خدمات بهداشتی درمانی شهید بهشتی

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Contents

Introduction

- Since dental implants were introduced for rehabilitation of the completely edentulous patients in the late 1960s, an awareness and subsequent demand for this form of therapy has increased.

- The use of implants have revolutionized dental treatment modalities and provided excellent long-term results.

- Titanium and titanium-alloys have become the preferred materials for dental implants owing to their good biocompatibility, excellent corrosion resistance and suitable mechanical properties.

Introduction

- The success or failure of an implant is determined by the manner that the stresses at the bone-implant interface transfer to the surrounding bones.

- In evaluation of the long-term success of a dental implant, the reliability and the stability of the implant-abutment and implant bone interface plays a great role.

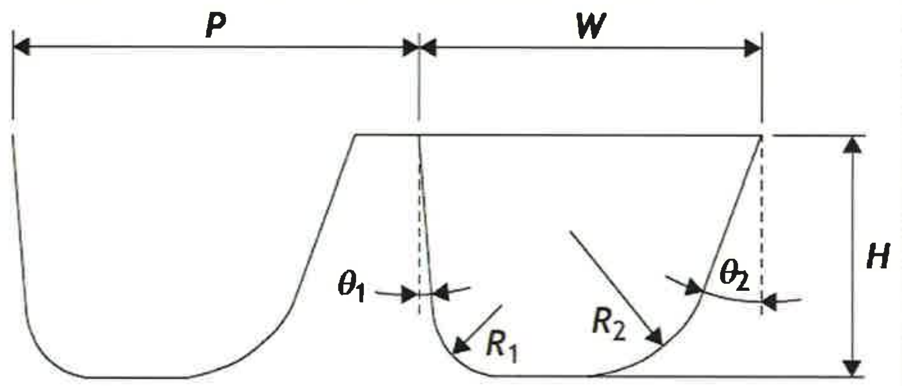
- A stress shielding or concentration can be easily induced on the interface and results in a potential risk to the long-term stability of the implant.

Osseointegration(osseocoaptation and osseocoalescens)

- Thread shape is an important objective in biomechanical optimization of dental implants.
- Threads are used to maximize initial contact, improve initial stability, enlarge implant surface area, and favor dissipation of interfacial stress.
- It is necessary to evaluate the thread design of dental implant to enhance further clinical success.

Introduction

- Implant thread
  - *Pitch*
  - *Height*
  - *Width*
  - *Type*
    - *Root radii*
    - *Flank angle*



Introduction

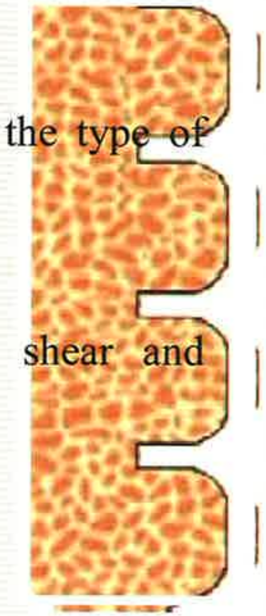
- Thread pitch
    - *Parallel distance between one thread and adjacent one*
    - *If the forces is high , the thread pitch must be smaller*
    - *Increased number of thread ,increased functional contact surface*
    - *Increased number of thread ,decreased stress loading to bone*
    - *Increased number of thread ,increased primary stability*

Introduction

- Thread type

  - Type of thread can influence force distribution and change the type of force that transfer to the bone.
  - For example in square type thread, amount of stress in shear and compressive force was lower than V-shape and inverted buttress.

    - *Square* $(\theta_1 = \theta_2 = 0)$
    - *V-shape* $(\theta_1 = \theta_2 = 30^o)$
    - *Buttress* $(\theta_1 = 5^o, \theta_2 = 30^o)$
    - *Inverted buttress*



Introduction

- In this work effect of different designs on stress distribution of dental implants using finite element method were evaluated.

- The finite element method (FEM) is a numerical technique for finding approximate solutions of partial differential equations (PDE) as well as integral equations.

Methods and Materials

Preparation of Models:

Implant

Mandible Bone

Data from CT

Diameter ~ 4 mm

Reconstructio

Length ~ 12 mm

Regions in vic

emo

Gingival latera

Abutment dimensions

5 m

Diameter = 3 mm

Length = 2.5 mm

Considered for all types

Certain Internal Connection | Tapered Certain Internal Connection | iti | spi | m | s

Methods and Materials

Material Properties

Boundary Conditions

Loadi

Mesh.

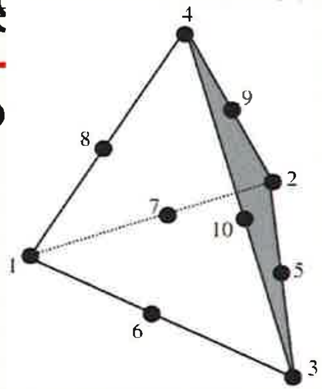
Axial load, 114.6 N

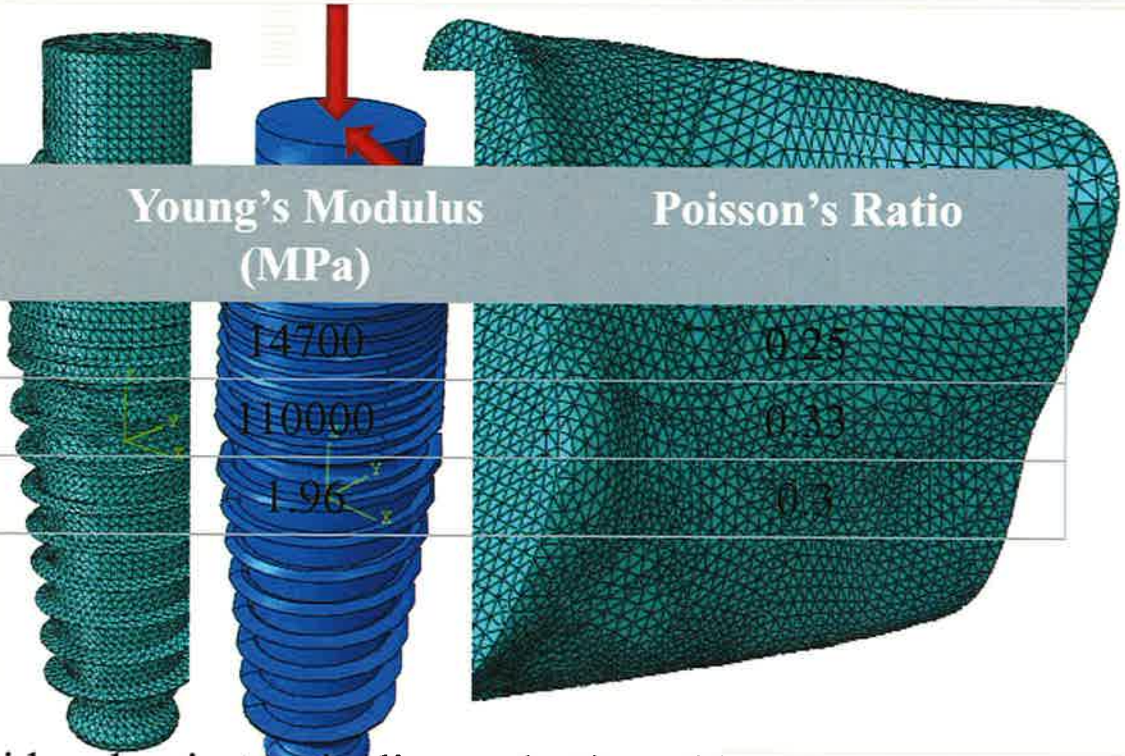
Static Analysis

Me … 23.4 N

Co … nt

va





Material	Young's Modulus (MPa)	Poisson's Ratio
	14700	0.25
	110000	0.33
	1.96	0.3

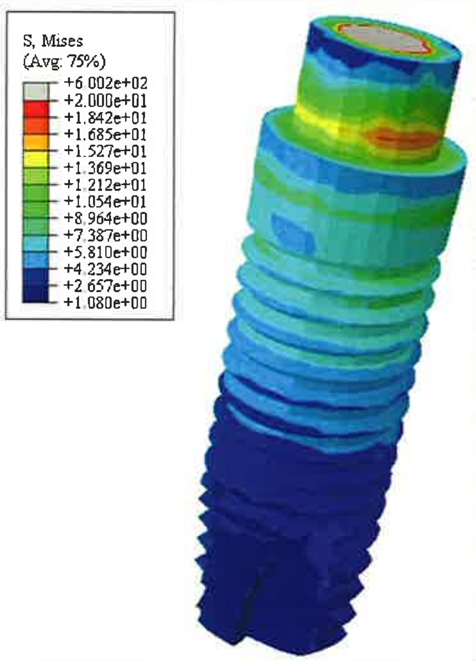
All materials are considered as isotropic, linear elastic and homogeneous.

10-node Quadratic Tetrahedral Elements

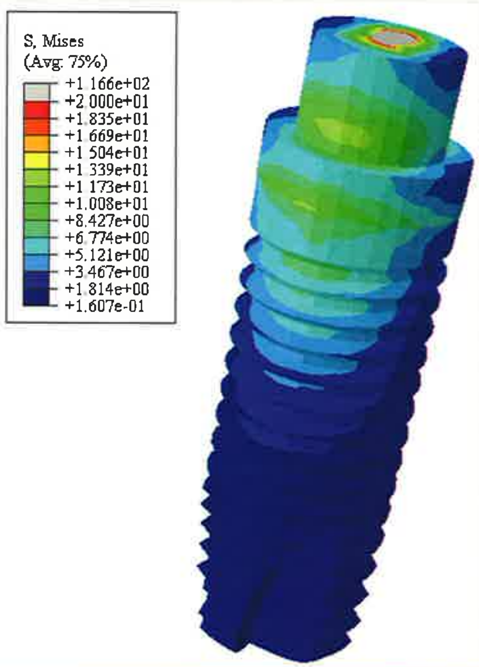
Results

Stress Distribution in 3i (Certain Internal Connection) Implant

Axial



mesiodistal



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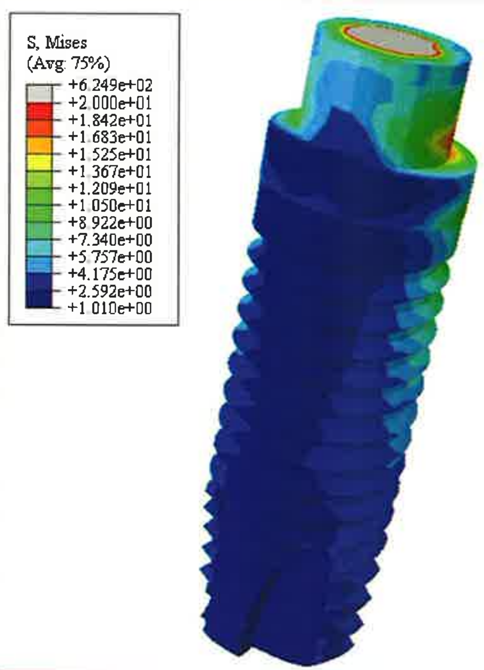
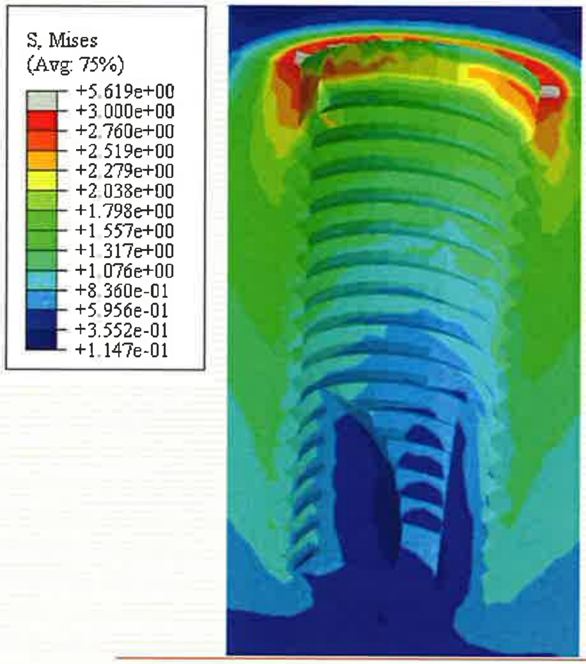


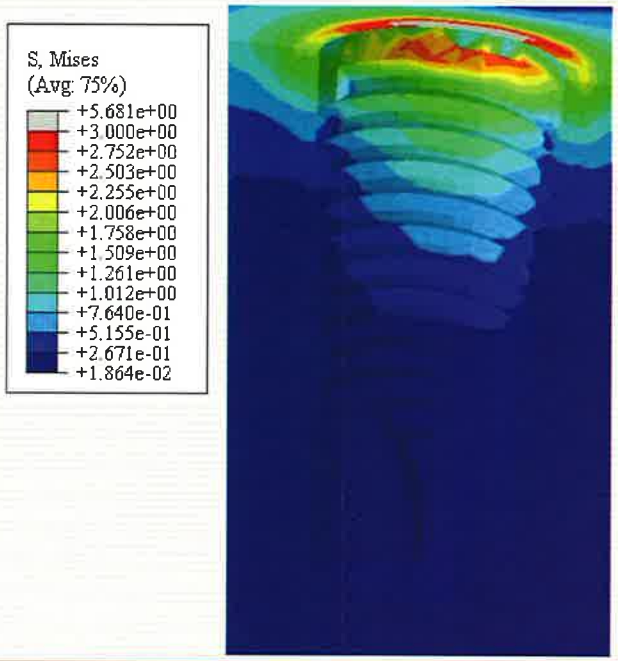
Results

Stress Distribution at Bone-Implant Interface

Axial



Mesio-distal



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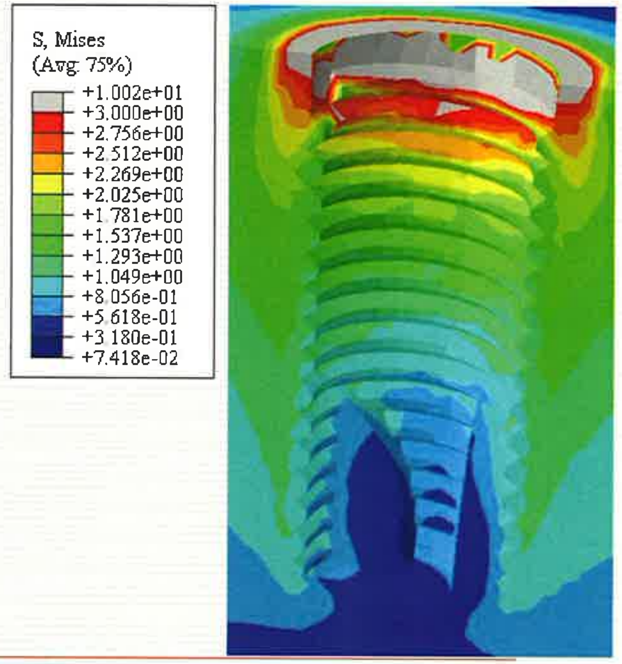
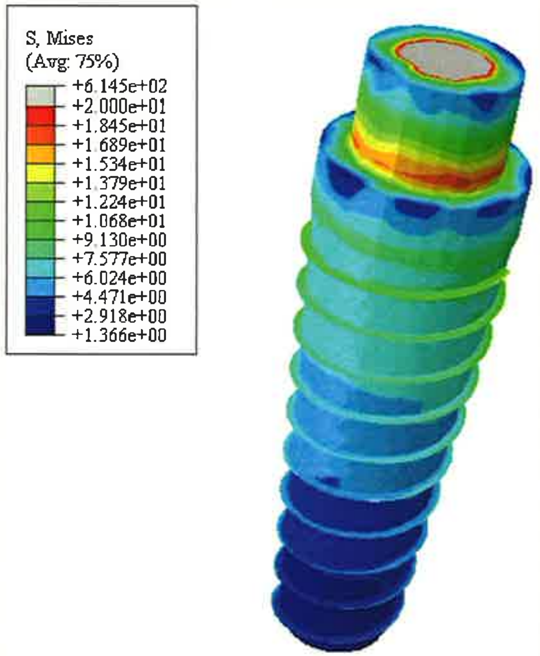


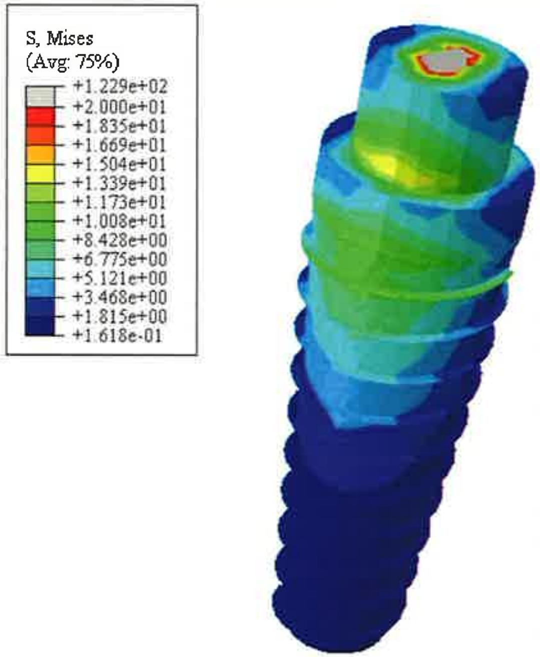
Results

Stress Distribution in 3i (Tapered Certain Internal Connection) Implant

Axial



Mesio-distal



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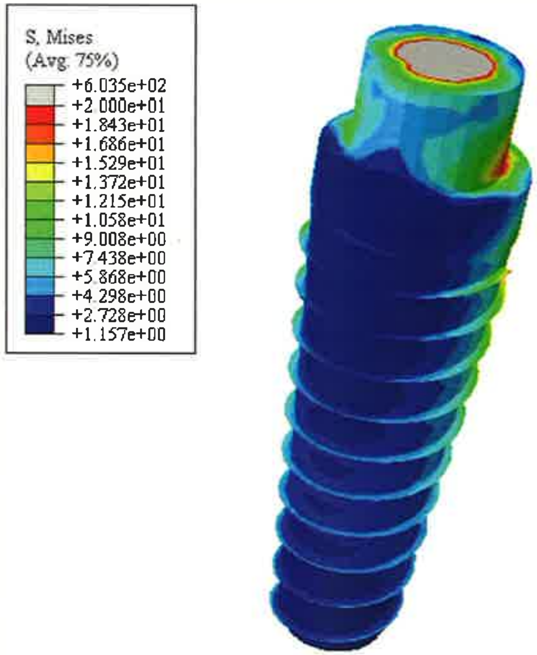
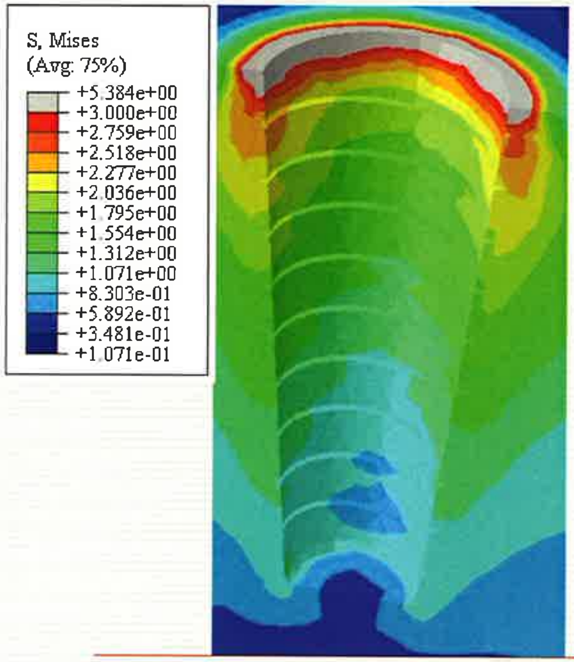


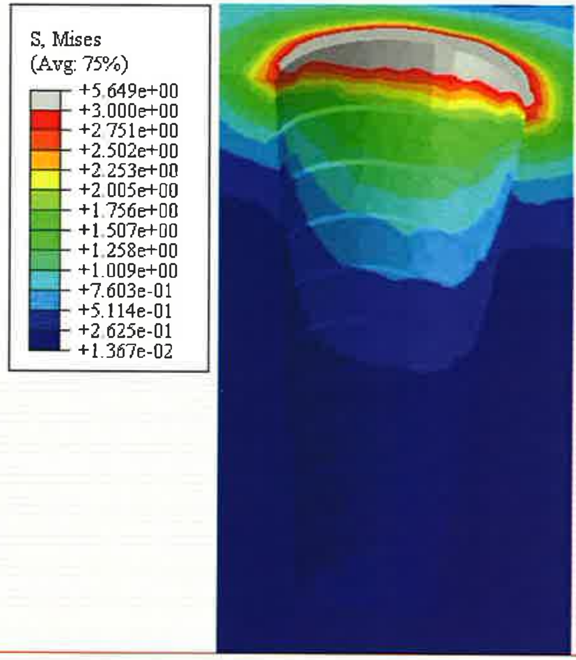
Results

Stress Distribution at Bone-Implant Interface

Axial



Mesio-distal



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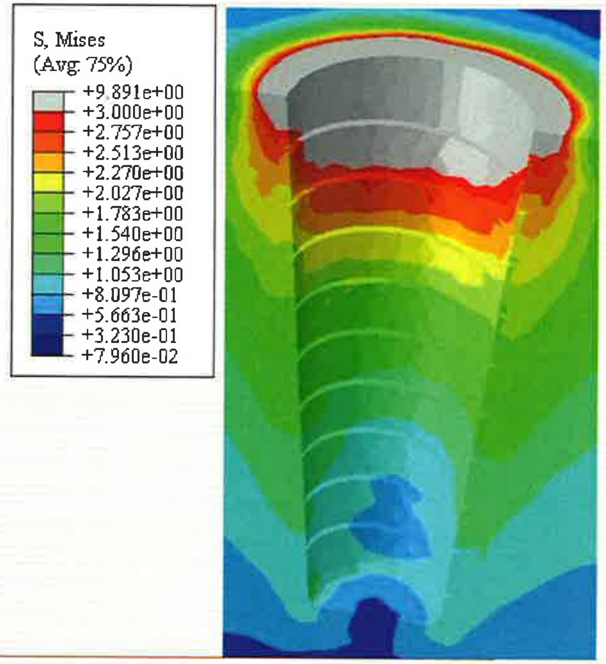
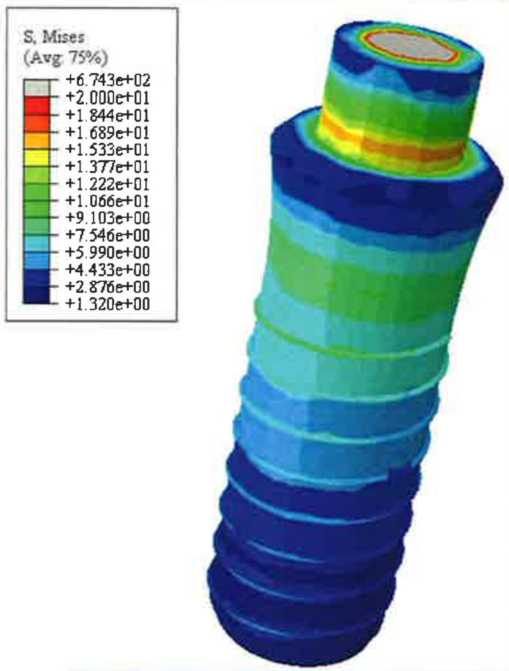


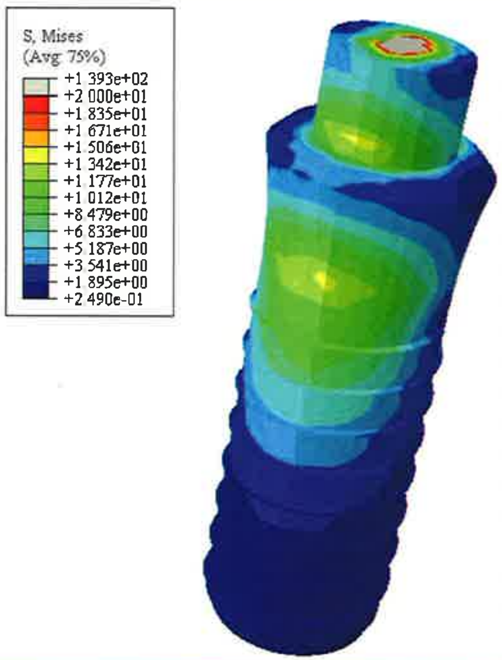
Results

Stress Distribution inITI Implant

Axial



Mesio-distal



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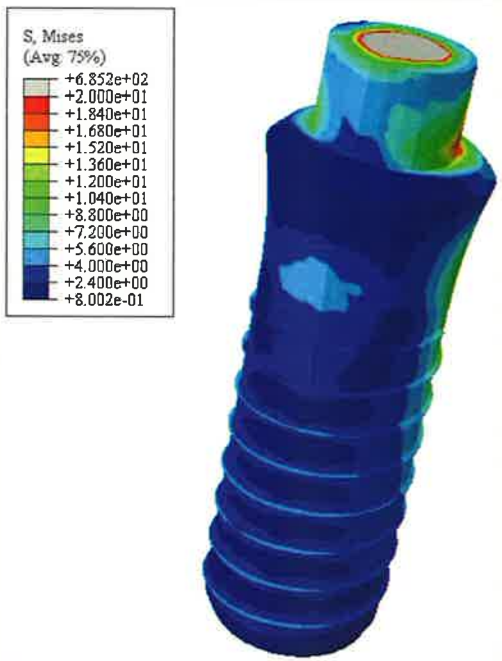
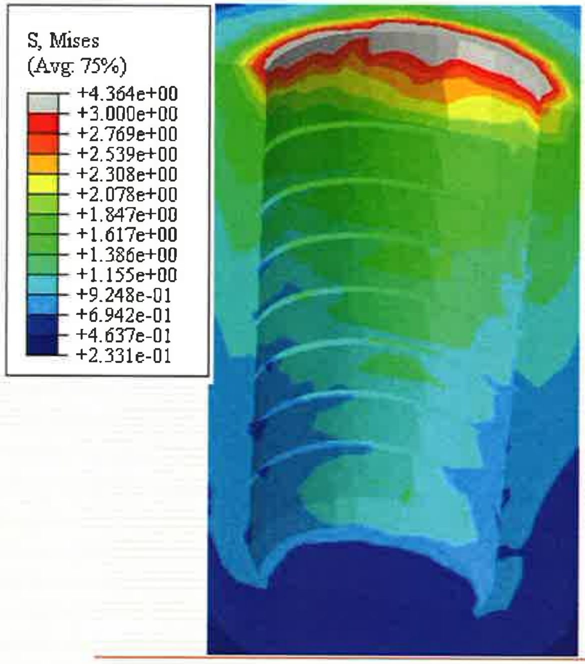


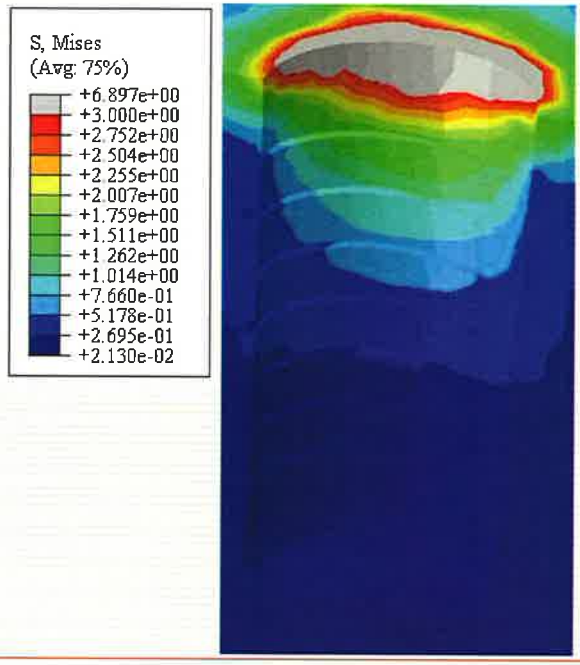
Results

Stress Distribution at Bone-Implant Interface

Axial



Mesio-distal



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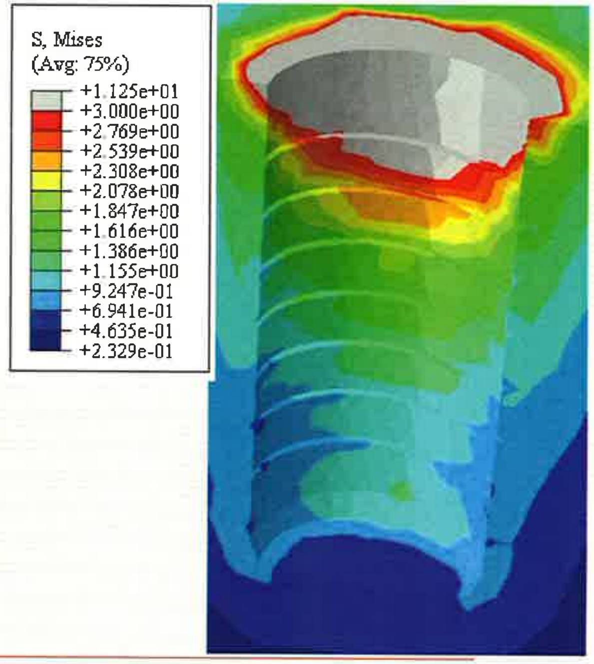
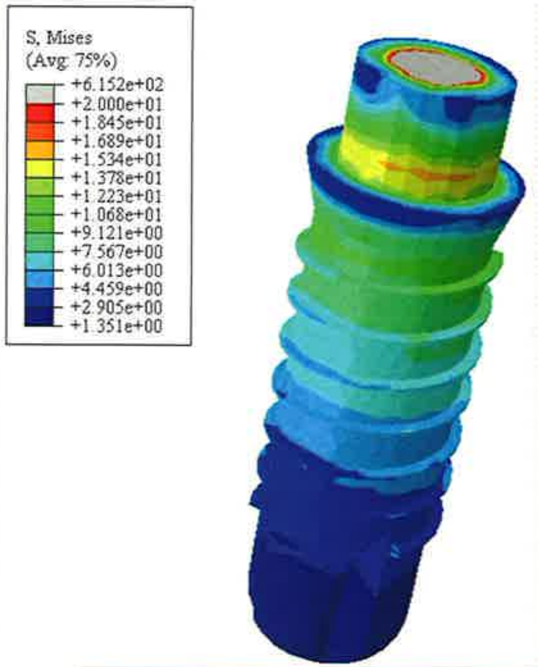


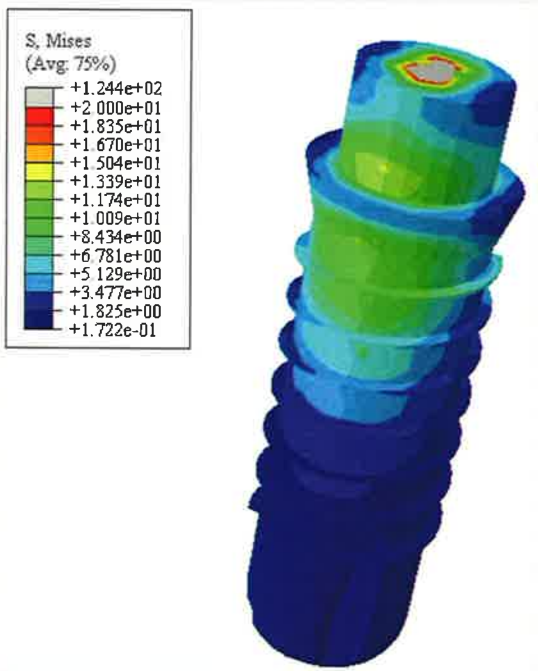
Results

Stress Distribution in SPI Implant

Axial



Mesio-distal



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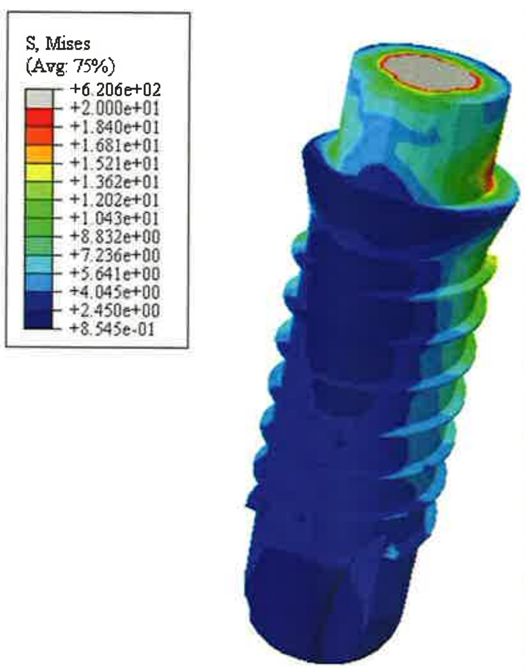
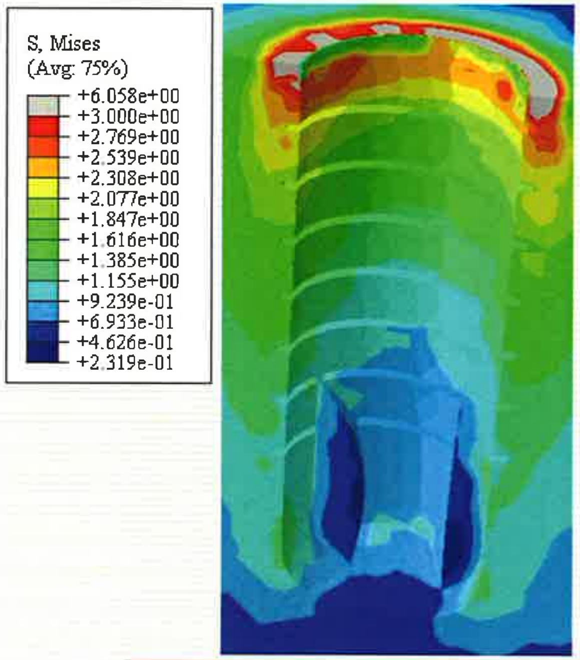


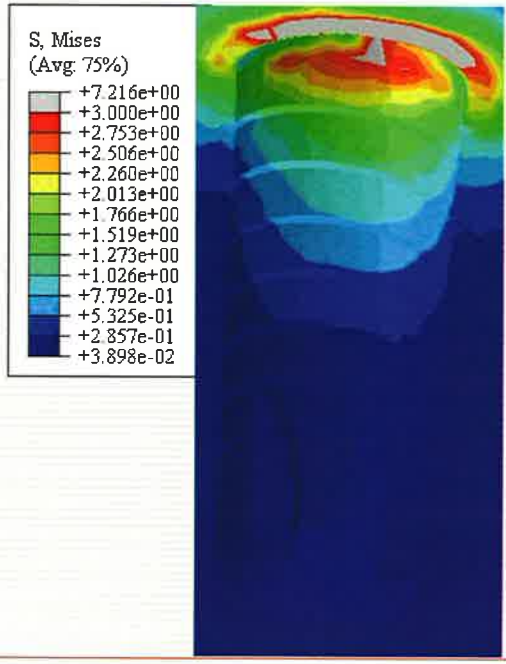
Results

Stress Distribution at Bone-Implant Interface

Axial



Mesio-distal



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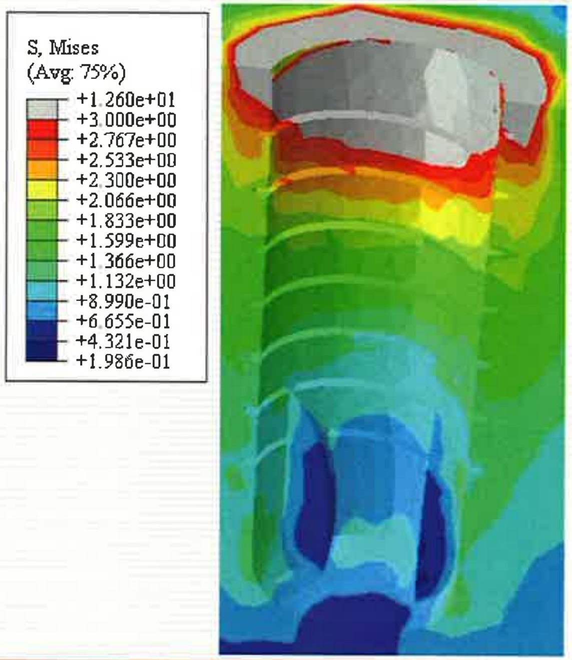
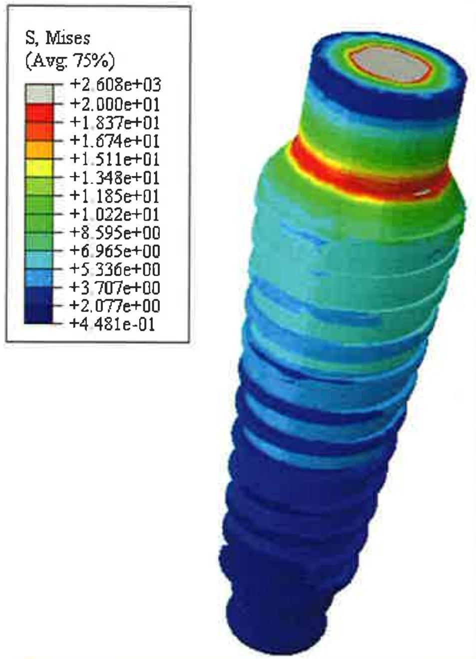


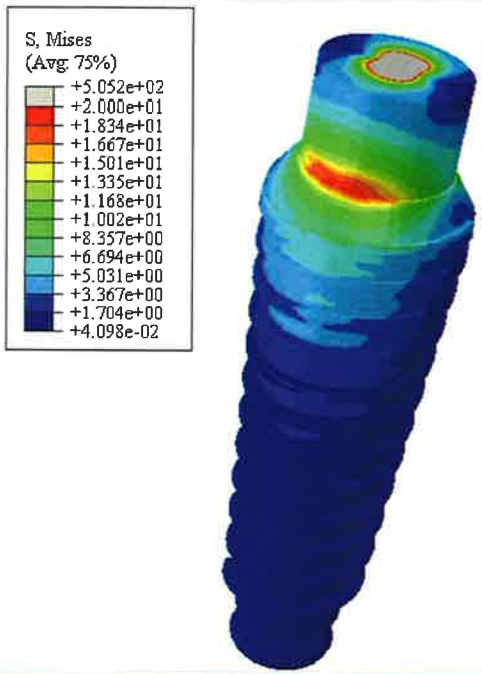
Results

Stress Distribution in IDCams Implant

Axial



Mesio-distal



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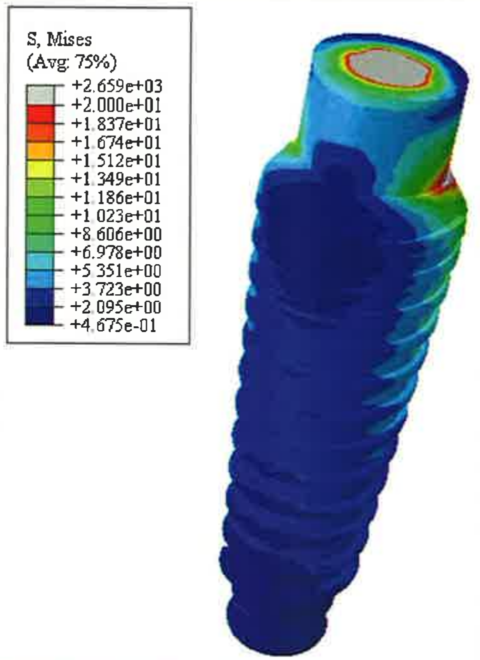
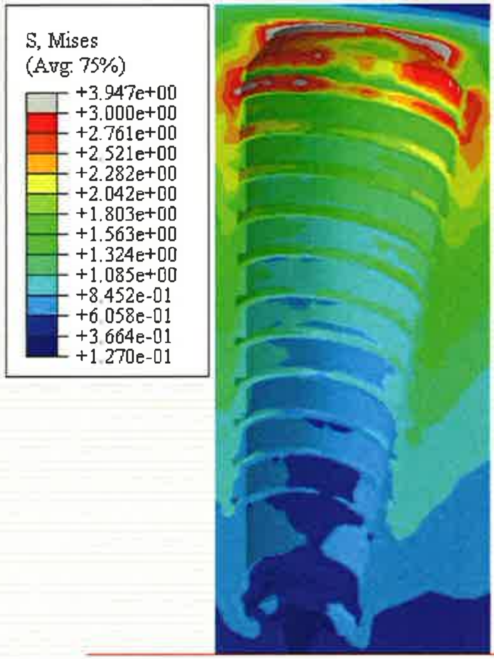


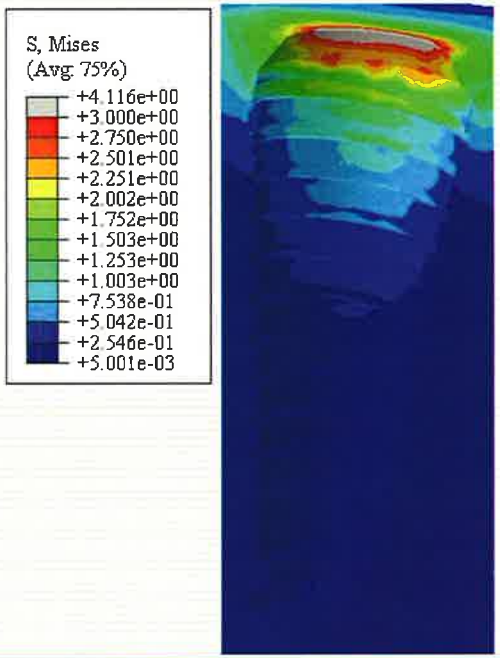
Results

Stress Distribution at Bone-Implant Interface

Axial



Mesio-distal



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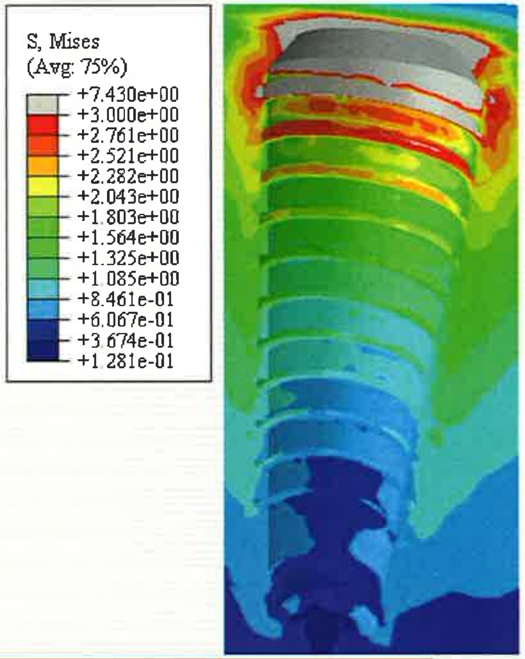
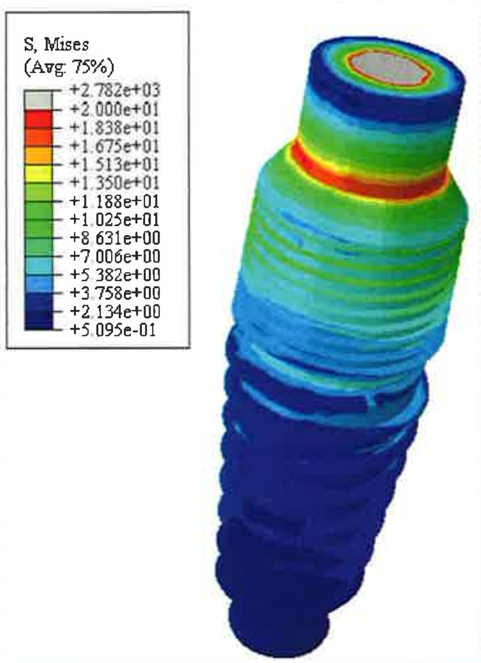


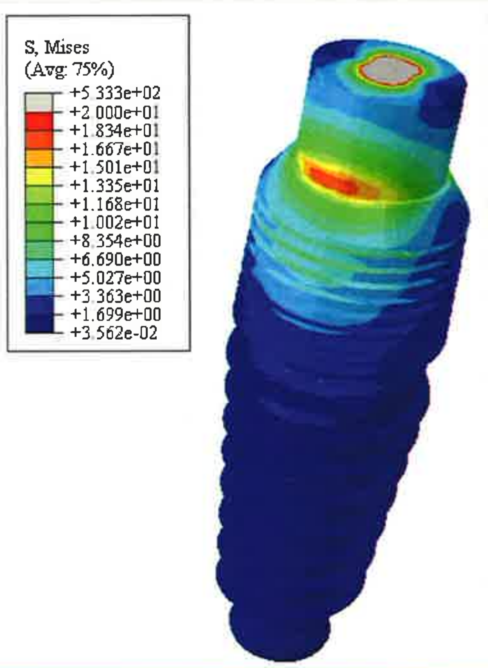
Results

Stress Distribution in IDCamm Implant

Axial



Mesio-distal



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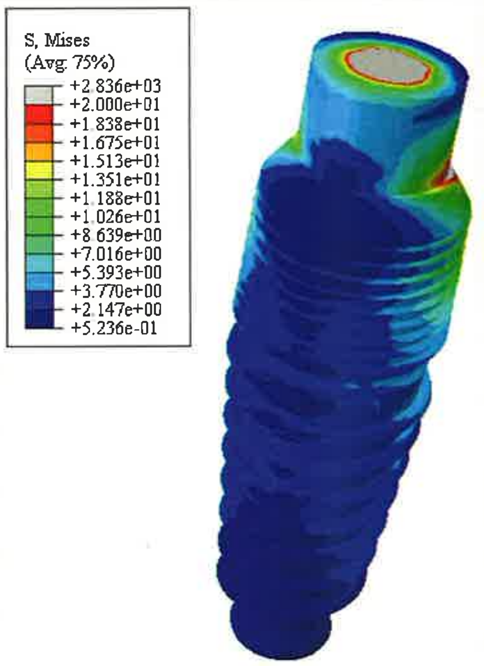
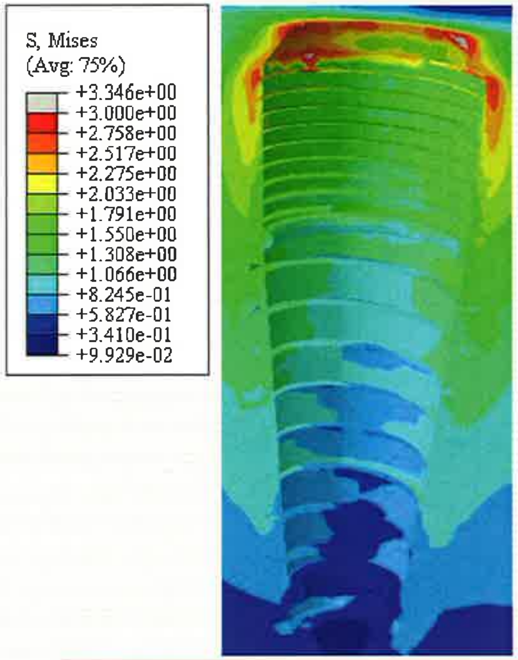


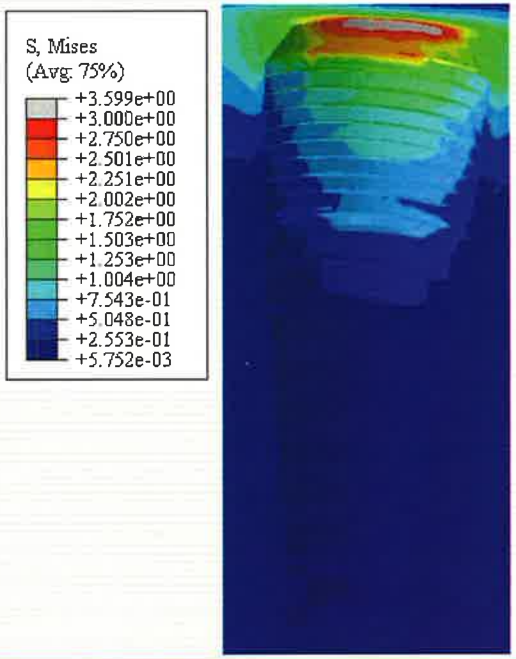
Results

Stress Distribution at Bone-Implant Interface

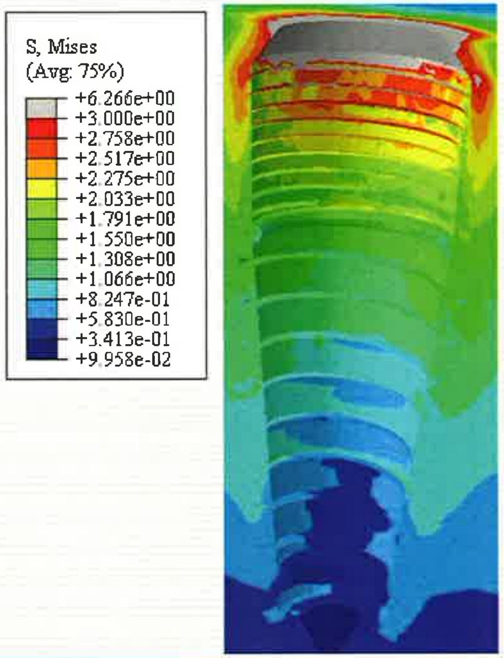
Axial



Mesio-distal



Combined



Results

Von Mises Stress occurred in Implants (MPa)

Type	Axial (114.6 N)		Mesio-distal (23.4)		Combined (116.96,78.45^0)	
	Max	Min	Max	Min	Max	Min
3i (Certain Internal Connection)	16.53	1.08	12.37	0.16	22.35	1.01
3i (Tapered Certain Internal Connection)	17.79	1.36	13.26	0.16	27.55	1.15
ITI	16.28	1.32	14.44	0.24	26.86	0.80
SPI	17.50	1.35	13.20	0.17	25.42	0.85
IDCams	21.26	0.44	20.42	0.49	39.53	0.46
IDCamm	20.40	0.50	18.34	0.03	36.16	0.52

Results

Maximum Von Misses Stress at Bone-Implant Interface (MPa)

Type	Axial	Mesio-distal	Combined
3i (Certain Internal Connection)	5.62	5.68	10.02
3i (Tapered Certain Internal Connection)	5.38	5.64	9.89
ITI	4.36	6.897	11.25
SPI	6.06	7.26	12.6
IDCams	3.94	4.11	7.43
IDCamm	3.34	3.59	6.26

Discussion

- Mesio-distal loads may affect more adversely rather than axial loads.
- Surrounding bone at its interface with IDCam received lower share of stress due to more dissipation of the stress by the implant.
- All types of the investigated implants experience stresses below the tensile yielding limit of Titanium-alloy equals with 500 MPa.
- Surrounding bone also experiences stresses below the tensile yielding limit of cortical bone equals with 114 MPa.
- A more reliable result thoroughly incorporating all aspects of an implant requires a fatigue-related simulation.

Discussion

- With respect to Bone Remodeling based on Frost theory, the mechanical stimulus received by majority of the osseous regions around the implant should be above the apposition limit of the bone remodeling, as stated below:

$$\Psi\ (t,x) > (1+\delta),\ \textit{apposition}$$

$$\Psi\ (t,x) < (1-\delta),\ \textit{resorption}$$

  where bandwidth of the lazy zone in bone remodeling, δ, is 0.1, and ψ is strain energy density (SED) calculated by FEM.

- Developing a more comprehensive conclusion relies on considering all biological and mechanical conditions of a natural case.

Thanks for Attention