

4. Finite Element Analysis

4.1 Introduction

After the three-dimensional models are created, they must be imported into finite element software for processing prior to analysis. The material properties of cancellous, cortical, and titanium implants are all obtained from the literature. The elements used for meshing the models are selected from the library of the finite element software. Finally, boundary conditions and loadings are applied for stress analysis.

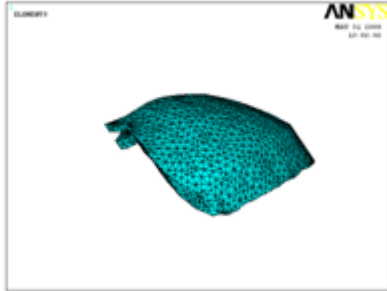


Figure 4.1: Meshing model

4.2 Materials Properties

In the absence of information about precise organic properties of the cancellous and cortical bone, they are assumed to be homogenous, isotropic and linearly elastic. Hence, all materials used in the models are considered to be homogenous, isotropic and linearly elastic, as frequently assumed by many authors. Elastic modulus of 108GPa and Poisson's ratio of 0.30 obtained from the values used by Lang et al (2003) is selected for the titanium implant and the elastic moduli and Poisson's ratio of cortical bone is same as that used by O'Mahony et al (2001) in studying the effect of anisotropic elasticity of cortical and cancellous bone on stress and strain in posterior cranium. Finally, the varying elastic moduli of the cancellous bone for the different bone types follow that of Tada et al (2003) in their findings of the influence of bone quality on stress and strain distribution in bone around implants. The material properties of all the entities are summarized as follows:

Table 4.2: Material properties used in analysis

Property	Young's Modulus	Poisson's Ratio
Titanium implant	108500	0.3
Cortical bone	14400	0.3
Cancellous bone	9500	0.3

4.3 Elements and Nodes

Finite element model required in the analysis is created by discretizing the three dimensional CAD model into smaller and simpler elements. This process is known as meshing. Because the model is symmetrical about the mesiodistal plane, only half of the model is meshed to shorten the processing and analysis time.

Differences in the mesh pattern may result in quantitative differences in the stress/strain values in the models and compromise the comparison between the values obtained for the different models. Therefore, it is important to derive the

finite element models with a single mesh pattern. In this study, the element types chosen is shell93 in the library of ANSYS, an eight-node tetrahedral element which is better suited for and more accurate in modeling structural solids with curved boundaries. The physical interactions between the surfaces of each entity are taken into account assuming that the different entities are perfectly bonded to each other. The meshing of the models results in a total of 2890 elements and 5870 nodes for Model.

4.4 Constraints and Loads

The models are constrained in all directions at the nodes on the top surface of the bone model. And since only half of the model is meshed, symmetry boundary conditions are prescribed at the nodes on the symmetry plane, which in this case, is the buccolingual plane. Forces of 100N are applied axially to different positions on the artificial skull ridge according to three cases (Figure 23), as follows:

Case 1 (Loading position 1, 2, 3): Three vertical forces applied from the upper left incisor to canine

Case 2 (Loading position 4, 5, 6): Four vertical forces applied from the upper left first premolar to molar

Case 3 (Loading position 6, 7): Two vertical forces applied on the two upper left molars as shown in figure 4.2

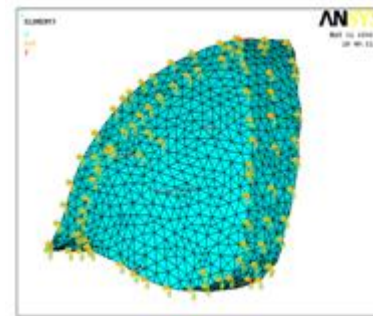


Figure 4.4: Applied boundary conditions and three loading conditions – Case 1, Case 2, and Case 3 (left to right)

Analysis with skull having a linear elastic property shows a uniform rise in shear stress and von-Mises stress value in cranium. But the locations of maxima are same, i.e. in the cranium stem region. In case of the level of von-Mises stress was much higher. The maximum von-Mises stress obtained adjacent to the titanium was 3.605 MPa. 3-D static of analysis gives the following variation of maximum von-Mises stress and maximum displacement with time.

However, in high Stress values are observed in the thin cortical bone layer, resulting in undesirable stress concentrations. Maximum stress occurs in the bone-implant interface region at the base of the implant in the cancellous bone (Figure 23) and also at the region around the neck of the implant in the cortical bone (Figure 23) for both the models.

In the titanium implants, higher stress is observed with the exception of that for Case 1 loading condition. The stresses are well-distributed with the maximum stress located at the tissue area surrounding the implant. The stress is well-distributed in both models with the maximum value located at the region surrounding the implant (Figure 23). In the

cranial implant, high stress magnitude of 23494 MPa is observed for Case 2 loading condition. (Figure23).

When comparing the different bone types, the results obtained showed similarities in all the three types of bone. Only a slight increase in maximum stress values is observed in the cortical bone layer when the Young's modulus of the cancellous bone is decreased.

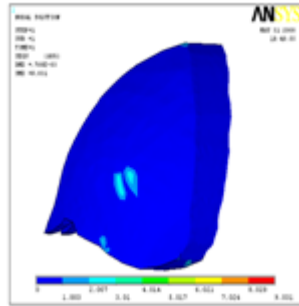


Figure 4.4.1: Stress distribution in cortical bone; case 1 loading condition

5. Conclusion

Both the Defected portion and the Designed portion of the left forehead of the Physical part are displayed for your reference. The main thesis, Using Rapid prototype part how we can go for manufacturing a customized Implant by various techniques in Castings like, Investment casting. This Customized Design Implant is now ready for Rapid Tooling for Rapid Manufacturing and for Direct Implant to the Patient. By Using this Techniques We can reduce the Lead-time of the Design and Manufacture the Implant.

The model consisted of 2890 elements through 5870 nodes. It was observed that the maximum von-Misses stress was around 9.031 MPa and maximum shear stress was 20.04 MPa that occurred in cranial stem. Also observed that stem is most vulnerable to shear. Total stress contour map revealed that the average Von-Misses stress generated in most of the areas was below 0.490 MPa. In case of the skull, level of von-Misses stress was much higher

1. A thinner cortical bone layer and less cancellous volume results in higher stress concentrations in the cortical bone.
2. Stress concentrations are found mainly in areas surrounding the plant.
3. Bone qualities do not contribute to changes in stress distribution or stress values in the cranial implant supported model.

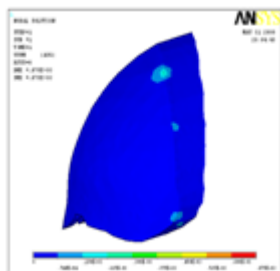


Figure 4.4.2: Stress distribution in cancellous bone; case 2 loading condition

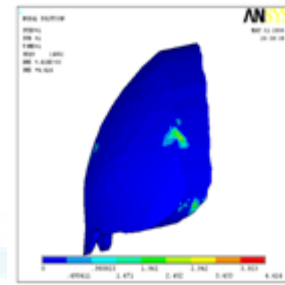


Figure 4.3: Stress distribution in titanium implant; case 3 loading condition.

References

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