Stress Analyses of Post Operated Fractured Human Mandible

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Abstract: The symphysis (mid part of the mandible bone) is one of the most frequently fractured regions after traumatic events involving the mandibular fractures. Rigid internal fixation is routinely used for surgical management of mandible fractures. The stability of the operated mandible during functional activities takes the premier place in this technique because movement at fracture line is a known considerable factor for both fracture and non-union. Thereby the ideal plate-screw system must be strong and rigid enough to withstand the functional loads and enable undisturbed fracture healing. A too rigid plate will lead to bone loss. In past decades, finite element analysis, based on material property to determine the distribution of stress and strain in Dental practices. In this present F.E study the efforts are made to compare some frequently usable plate-screw fixation techniques used for treatment of symphyseal fracture. In our proposed study, two fixation techniques were taken into consideration on the basis of dimensional criteria (Thickness & length of the plates and diameter of holes) of the titanium plates and these techniques were assessed for distribution of stresses induced in the fractured mandible and fixation devices after the operation In our results mean stress and von-mises stresses were higher for fixing technique microplates based technique and lower for miniplate based fixation technique.

1 Introduction

I.F (Internal Fixation) is commonly used for surgical treatment of mandible (roughly, lower jaw) fractures after traumatic events. Fractures that require surgical fixation with plate and screw system may attain immobilization through fixing titanium plates and associated screws. After the treatment and during healing process of the fractured mandible after the various force vectors and associated biomechanical stresses & strains take place due to usual daily activities in which mandibular functions as; nibbling, eating, masticaion etc. Previous researches have already described the bio-mechanical distribution of a mandible that fractured at the angle or condylar process after reduction with miniplates using FE analysis[1]. However the symphyseal fracture has not yet been explored much. Mandible fractures are a frequent injury due to prominence of the mandible and relative lack of support[2]. Symphysis Fracture, in the region of the central incisors that extends from the alveolar process through the inferior border of the mandible. Fractures that occur in the midline of the mandible are classified as Symphyseal. Rigid fixation in the fractured mandible

means to a form of treatment that consists of applying fixation to reduce the fracture and also permit active use of the mandible during the healing process. Computer-aided design and finite element methods (FEM) have interested dental researchers because of its use in the computer simulation and design of dental implants, a process greatly facilitated by the development of new computer technology and more accurate modeling technologies. FEM allows for a better understanding of stresses along the surfaces of an implant and in surrounding bone[3][4].Titanium miniplates and microplates are being used frequently. The use of miniplates has established as an efficient fixation technique for treatment of symphyseal fracture but the microplates are generally used for treatment of fractures occurred in the maxillofacial fracture because of lesser strength but the properties of having lower mass and lesser volume makes it the efficient potential prominent fixation technique. Although, the com-bination of miniplate and microplate has been proved as a successful fixation technique.

2 Objective

In this study our objective is to compare the postoperative biomechanical stresses induced in the system of fixation device and the mandible for symphyseal fracture (vertical line fracture in the symphysis reason of the mandible) for two types of fixation techniques; two titanium miniplates with four screws and two titanium microplates with four screws with the intact mandible through the CAD cum CAE software UNIGRAPHICS NX 9.0.

3 Materials and Method

In our study the two fixation techniques were considered namely, technique 1; two titanium miniplates (each having four screws) one fixed at upper side and other at lower side of the symphyseal fracture line and technique 2; two titanium microplates (each having four screws) fixed in the same location. Computer Tomography scanning of the prototype of human mandible or lower jaw (the same used in Dental College being proportional representative of the real Jaw) was done. With the help of CAD cum CAE software Unigraphics-NX 9.0, three digitalized models were created, model 1; the fractured mandible reduced by technique 1, model 2; the fractured mandible reduced by technique 2 and the model 3; the imperforated mandible. In our study we considered the bite force of 62.8 N on the incisor tooth as point load (avoiding freeway space) as the load condition with specific bite task. Both the condyles were treated as fixed. The intact mandible and the system of fractured mandible and the fixation devices in each of the three digitalized models were treated in the static equilibrium. Whole Masticatory muscles involved in biting tasks were simulated by the parallel vectors. The software protocol and procedures were followed to try to establish synchronization between the digitalized models of the mandible and the real postoperative situations. The important prerequisites and considerations were the materialistic and mechanical properties of the bone, screws & miniplates, kinematics & dynamics of the mandible, boundary conditions and other related parameters with some unavoidable assumption.

The material of the whole mandible is made of uniform, isotropic. and elastic

behavior. The young's modulus and poisson ratio were taken as 13700000000 N/m^2 and 0.3 respectively which is very competent as very researchers observed.[5]. For making simple surface to surface gluing hence the relative contact between the plates and mandible was restricted but the fractured faces were in surface to surface contact with coefficient of friction with value of 0.3. Various study suggests that average incisal force can be taken as 62.8 N[6] [7]. This force was taken for all the two techniques The titanium plate and screws are as per standard sizes as; For miniplate the thickness, diameter of hole and length were 1mm, 2.5mm and 28 mm. Similarly the same properties for microplates are 0.75mm, 1.25mm and 20mm. Each screw was determined to be in perfect contact and firmly fixed with the cortical and trabecular bone surrounding it and the miniplate (no slip and no clearance) as the design of Uni-locking plating system. Furthermore, the miniplates were assumed not to receive or transmit any force directly from the bone segments, rather, the chain of force transfer was defined as progressing from bone to screw, from screw to plate, and finally returning via the screws back to the bone. Two ends of the mandibles were assumed to be fixed for establishing static study[8].

4 Result and discussion

In our results, Symphyseal region was found the most stress borne area for all the three models and the site of maximum stress induced in each of the individual models was also the same(at the biting point). Stress distribution pattern in the mandible reduced with technique 1 was closer to that in the intact mandible. Both the techniques are rigid enough as fixation device. Technique 2 shows the higher maximum stress and means stress.

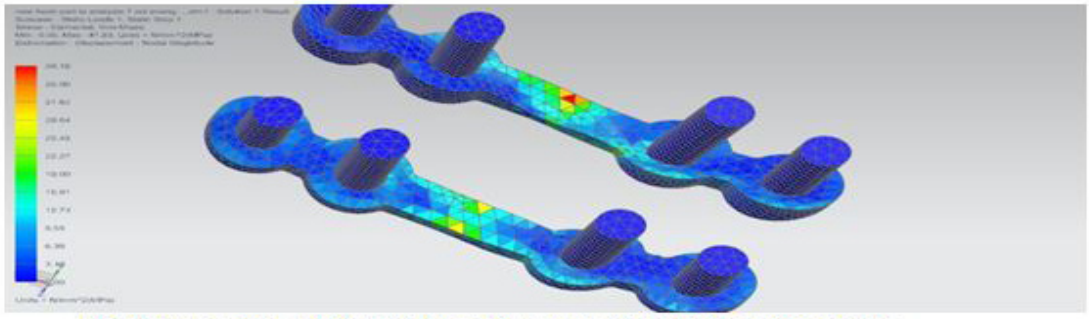

Figure.1.Elemental von-mises stresses in miniplates and screws

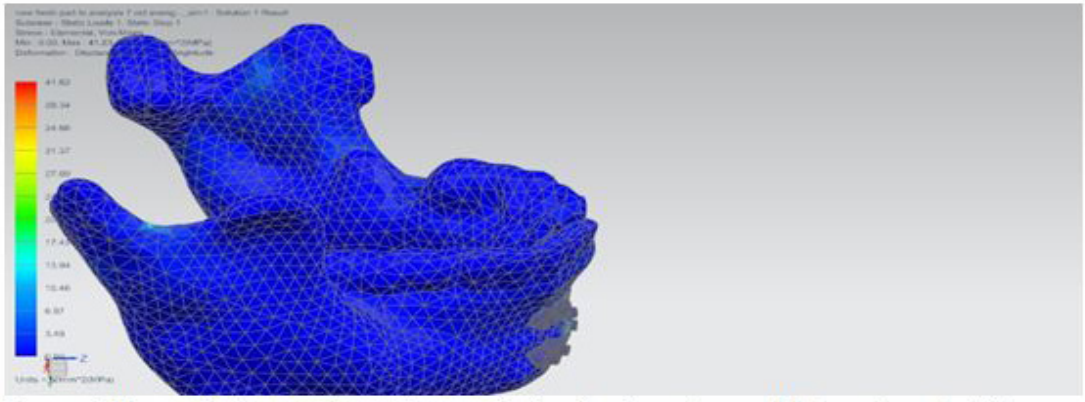

Figure.2.Elemental von-mises stresses in the fractured mandible reduced with miniplates.

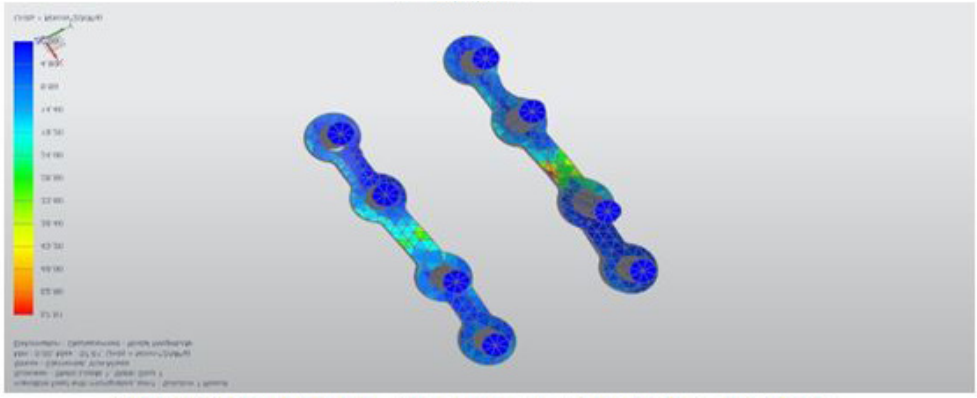

Figure.3.Elemental von-mises stress in microplates and screws

Table.1. Comparison of the results of the FEA based analysis for Fractured mandible fixed with miniplates, microplates and intact mandible

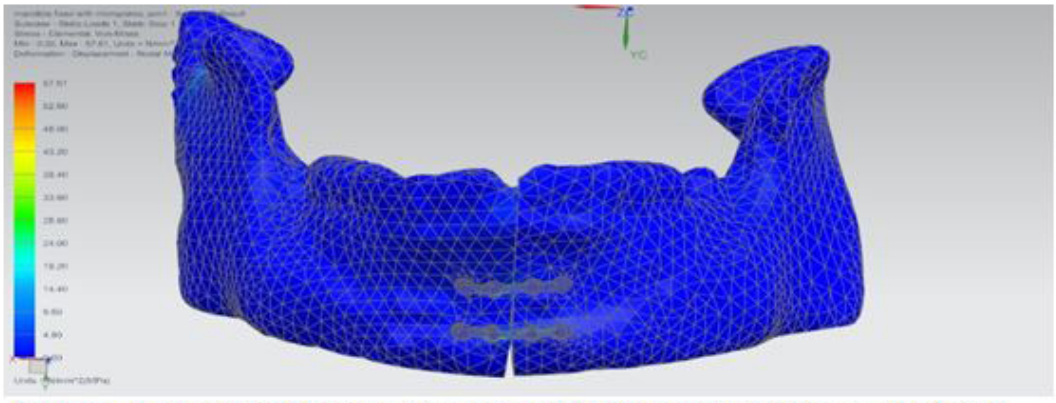

Figure.4. Elemental von-mises stresses in the fractured mandible reduced with microplates

Table.1. Comparison of the results of the FEA based analysis for Fractured man-dible fixed with miniplates, microplates and intact mandible

Name of the property	Fixed` with miniplates MPA	Fixed with microplates	Intact mandible
Displacement nodal in mandible	0.061	0.0713	0.0637
Displacement nodal in plates	0.0525	0.0607	-
Von-mises Stresses in miniplates	38.18	57.61	-
Mean stress in mandible	33.72	20	4.86
Von-mises stresses in mandible	41.83	57.61	51.15

Further, the use of microplates relies on the severity of the fracture and the anthropometry of the patient's mandible.

The fixation techniques affect the pattern and magnitude of stresses induced. operation In our results mean stress and von-mises stresses were higher for fixing technique microplates based technique and lower for miniplate based fixation technique. The mean stresses are also less for microplate based fixation.The streeses induced in the microplates are well below its yield strength and the benefits of using the microplates can be entertained. Both the techniques have the same stress distribution pattern as intact mandible.

It is recommended that two microplates can also be used as fixation device as It has a benefit of lesser bulkiness and occupy a less space in the mental foramen region of the mandible. The dissolution of some material of the titanium plates with the mandible bone due to chemical reaction during the long period of fracture healing. Further, the understanding of relative biomechanical advantage of the techniques relies on the severity of the fracture and the anthropometry of the patient.

5. References

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