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A Comparative Study of Most Suitable Miniplates Fixation for Mandible Symphysis and Parasymphysis Fracture using Finite Element Model (FEM)Analysis.

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I. INTRODUCTION

The mandible is the most frequent site among facial fractures. Fractures with displacements are often treated by open reduction and internal fixation using miniplates.[1,6,7] When planning a surgical strategy for mandible fractures, it is most important to obtain a rigid internal fixation to bear the masticatory load. Rigid fixation has been advocated as an early return to form and function for human mandible fractures.

While stabilization is as important for symphysis fractures as other mandibular fractures, there has been relatively little study on an optimal method of internal fixation. This may be because, as the shape of the symphysis region is simpler than that of the angles or condyles, surgeons could assume that differences in fixation methods were less important. Little data exist on the selection of the number and positions of a plate, and these decisions are typically made empirically.[3]

To address this uncertainty, we used dimensional FEA to investigate whether or not the stability of the fracture surface differs with different plating strategies.

The FEA is an acceptable research tool for understanding effect of different geometries in identical or similar groups. However, the anatomy, modeling, and material properties of the bone, dimension and the material properties of the implant system, implant surface structure, implant fixture design, binding conditions of the bone-implant interface, and loading conditions of the model have great importance on the results.[4,5.]

The objective of our study is to determine the most rigid fixation of mandidular symphysis, parasymphysis fracture by using 1.3mm & 2mm non compression miniplates & compare the variation in stress distribution and deformation between miniplates and to determine the sensitivity analysis for stresses in the mandible during mastication.

II. MATERIAL AND METHODS

A finite element of human mandible with symphysis and parasymphysis fracture was created and anatomically loaded with miniplates to determine the effect of fracture healing and to investigate whether / not the stability of fracture surface differs with different plating strategies.

Model creation

Computer models of adult human edentulous mandibles were created from CT scans of 8 dry human mandibles .

Every fifth coronal plane slice (1 mm each in thickness) was picked, commercial software used was Ansys. The mandible and related disks were modeled by both tetrahedral 4-noded element (first model) Hexahedral 8 noded element (second model). The mandible is further divided into fourteen sectors, characterized by varying stiffness properties.

The 8 mandibular models of different heights and widths were created. The coordinate data of mandibular models were imported to a personal computer . And all surgical simulations and analyses were performed using finite element analysis software (ANSYS Ver.12.1). Models were assigned with an orthogonal X-Y-Z coordinate system.The X-axis was assigned as medio-lateral, theY-axis cranio-caudal, and the Z-axis antero-posterior.

Symphysis and parasymphysis fracture lines were configured in the models. Titanium miniplates of 2mm and 1.3mm thick plates were modeled and positioned across parasymphysis, symphysis fracture lines.

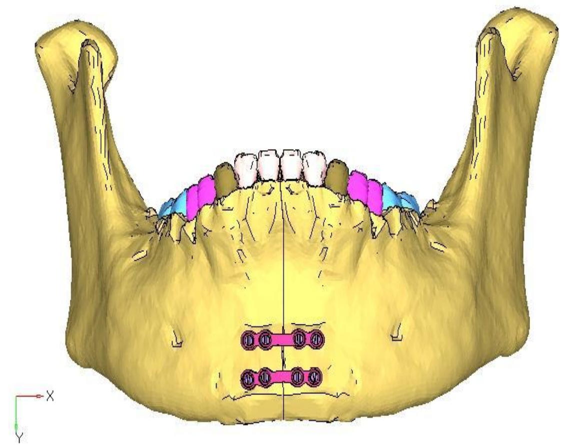

Figure 1:3D FEM Mandible model and bridged titanium miniplates

Constraints, loading, and Analysis

Six regions including condylar processes, coronoid processes, and mandible angles, were fixed to zero.

A masticatory load on the left molar region was simulated with a 150N, 200N, 250N, 300 N force perpendicular to the dental implant , which is the mean single molar bite force in healthy young adults. It was assumed that the maximum masticatory load was applied to the molar region through the implant during mastication.

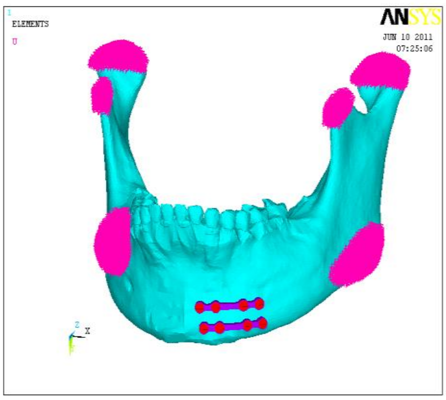

Figure 2:Six regions including condylar processes, coronoid processes, and mandible angles, were fixed to zero displacement

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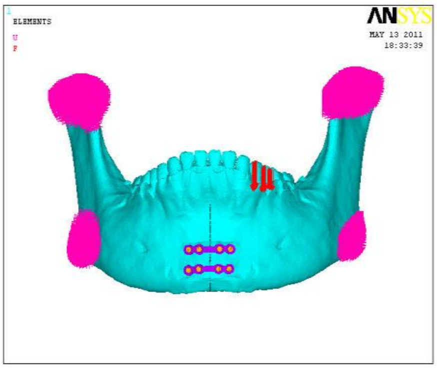

Figure 3:Vertical load of 150N,200N, 250N, 300N force applied on first molar

FEM models of fractured mandible, adapted titanium miniplates are imported into Ansys software.FEM software calculated the stress distribution across miniplates and the displacement across the fracture segments inferiorly according to the loading condition.

III. RESULTS

The mechanical changes observed in this study were evaluated under the following headings.

1. Maximum stress distribution in screw/plating system, around screw hole.
2. Displacement of fracture fragment inferiorly.

Models	**Maximum deformation (mm)**	**Maximum stress (Mpa)**
Symphysis fracture fixed with 1.3mm plates	0.26	338
Symphysis fracture fixed with 2mm plates	0.093	227
Parasymphysis fracture fixed with 1.3mm miniplates	0.19	360
Parasymphysis fracture fixed with 2mm miniplates.	0.08	72

Table1:Maximum displacement and maximum stress distribution among 1.3mm &2mm miniplate,where the loading condition is maximum,300N

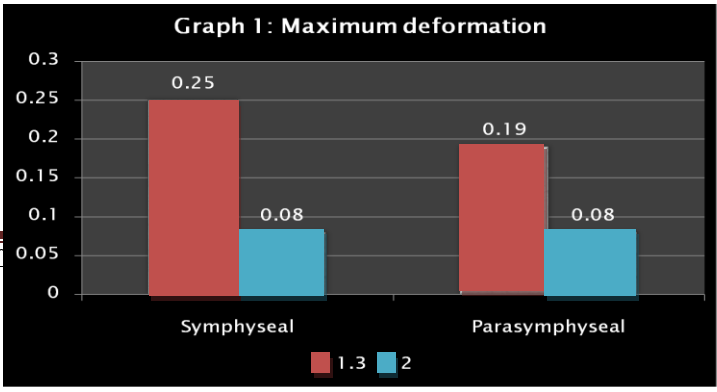

Fig4: Maximum displacement in 1.3mm &2mm miniplate

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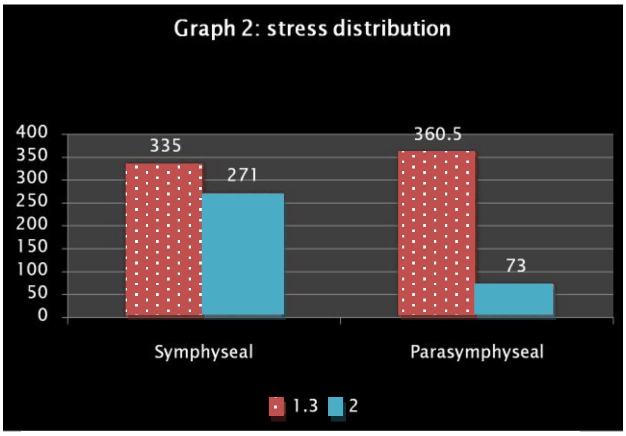

Fig5: Maximum stress distribution in 1.3mm &2mm miniplate configuration at symphysis and parasymphysis

Evaluation and statistical analysis

The maximum stress within the screw/plating system, and the maximum stress around the bone screw holes were evaluated.

Site	deformation	group	N	Min	Max	Median	p-value
Symphysis fixation model	Maximum deformation	1.3 mm	4	0.22	0.28	0.25	0.02
		2mm	4	0.06	0.09	0.08	
Parasymphysis fixation model	Maximum deformation	1.3 mm	4	0.16	0.2	0.19	0.021
		2mm	4	o.06	0.1	0.08	

Table 2: Statistical Analysis of Maximum Deformation

site		group	N	Min	Max	median	p-value
Symphysis	Maximum stress	1.3 mm	4	330	340	335	**0.02**
		2.00 mm	4	268	275	271	
Parasymphysis	Maximum stress	1.3 mm	4	358	362	360.5	**0.021**

Table 3: Statistical Analysis of Maximum Stress distribution

All stress values were recorded in MPa (Mega Pascal's ¼ N/mm2). Data were compared for significant differences using the Mann-Whitney U test, with P values< 0.05 being significant. All calculations were made using SPSS Ver.

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Comparing the 1.3mm miniplates and 2mm miniplates of symphysis and parasymphysis fixation models, mechanical stress within screw/plating system are differed. In symphysis, parasymphysis model fixed with 1.3mm miniplates, maximum stress was found within the screw/holes/screw plating system compared to 2mm fixation models

IV. DISCUSSION

Mandible fractures are among the most common bone injuries in facial trauma, currently mandible fracture repair is carried out with an appropriate osteosynthesis plate. These plates employed should ensure functional, mechanical,morphological rehabilitation.

Ultimate goal of open reduction and internal fixation of mandible fractures had been to eliminate the need for intermaxillary fixation and facilitate stable anatomic reduction while reducing the risk of postoperative displacement of the fractured fragments and allowing immediate return to function.[8,9]

Studies have shown that tortional forces generated during mastication were higher at parasymphyseal region and required double plate fixation for effective neutralization of the tortional stresses and providing optimal stabilization required for undisturbed healing of fractured bone.[3] [12]

The purpose of surgical fixation for mandibular fractures is to secure the reduced fragments during osteogenesis to permit sound healing. Inevitable frequent masticatory loads can cause motion at the fracture site, and interfere with the healing process. As a result, nonunion can occur in symphysis fractures, the rate of which has been reported to be 3.7%.[2 4]

Therefore, we used most effective miniplates fixation to stabilize fracture, which results in less mechanical stress on the mandible. Maximum displacement was measured by displacement contours. Color coding in the displacement contours indicates displacement at different regions in the mandible. so maximum displacement is associated with 1.3mm plates.

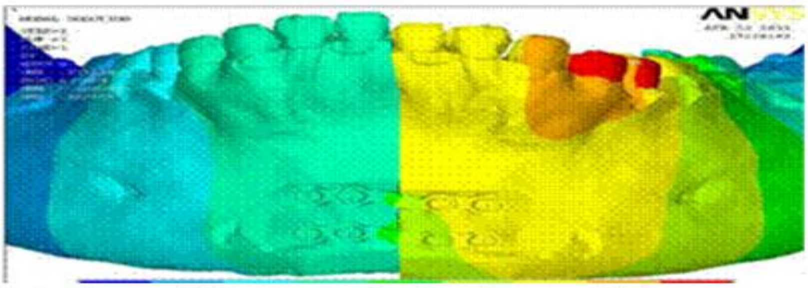

Fig 6 : **1.3mm miniplates in symphysis region** Minimum displacement = 0.0026 mm(blue colour) Maximum displacement = 0.26 mm (Red colour)Colours in between blue and red shows the displacements at different regions in the mandible

The contour map of intact mandible model showed that von misses stresses decreased gradually with distance from the loading region.

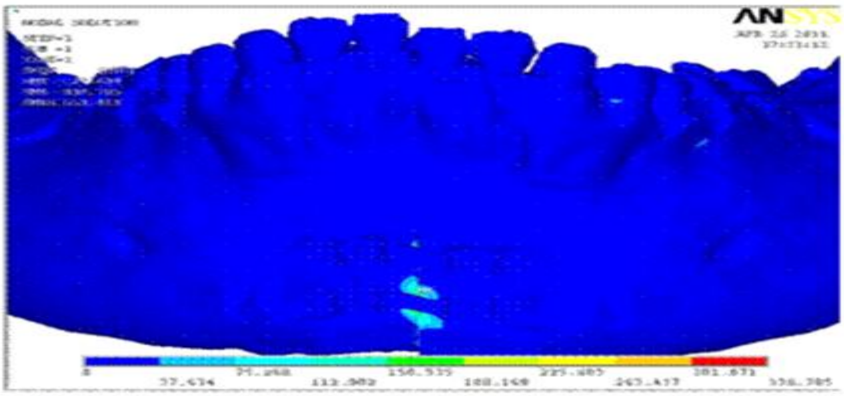

Fig 7 : Blue colour indictaes minimum stress value .Red colour indicate maximum stress values Maximum stress = 338MPa

Colours in between blue and red indicates the stress values at different regions of the mandible

The attractive feature of finite element is the close physical resemblance between the actual structure and its finite element model.

Excessive simplifications in geometry will inevitably result in considerable inaccuracy. The model is not simply an abstraction; therefore, experience and good engineering judgment are needed to define a good model.

2-D models cannot simulate the 3-D complexity within structures, and as a result are of little clinical values. The group of 3-D regional FE models is by far the largest category of mandible related researches.[17]

In symphysis, parasymphysis fracture, the fracture stability will differ with different dimensions of plates and screw .

We created 3 –dimensional mandibles models to simulate the different dimensions of non compression miniplates for symphysis and parasymphysis fracture models.

In vivo strain gauge measurements are alternative to FEA[10 11], but stress-measuring areas and the number of measuring devices are limited due to the volume of the gauge. FEA permits an analysis of stress from arbitrary points, and provides other useful information such as on distances, stress, and behavior of the whole model. There are many reports on FEA for angle fractures[13], condylar fractures[15], and other mandibular conditions.

The masticatory load we simulated was a 300 N vertical load on the left molar region. While masticatory motion is actually like a teardrop cycle[12], which mean the frontal plane trace of a molar is like a teardrop not a straight line, the vector mostly consists of a vertical component. So we considered a vertical load to be a reasonable approximation.

V. CONCLUSION

Literature mentions about the efficient usage of 1.3 mm plates in simple mandible fractures. This in vitro FEM Evaluation reveals that the variation and displacement contours and stress observed in 1.3 mm plates was significant when compared to 2 mm plates at 300N.

Hence, the 2mm non-compression miniplates were found to provide rigid fixation & less stress distribution at screw hole, around screw/plating above 300N

REFERENCES

[1]. Erol B, Tanrikulu R, Go¨ rgu¨ n B: Maxillofacial fractures. Analysis of demographic distribution and treatment in 2901 patients (25-year experience). J Craniomaxillofac Surg 2004; 32: 308–313

[2]. Al Ahmed HE, Jaber MA, Abu Fanas SH, Karas M: The pattern of maxillofacial fractures in Sharjah, United Arab Emirates: a review of 230 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004; 98: 166–17.

[3]. Kimura A. et al. Comparative study of most suitable miniplate fixation for mandibular symphysis fracture using a finite element model. Keio.J Med2006;55:1-8.

[4]. Van staden RC ,Guan H, Loo YC .Application of finite element method in dental implant research ,computer methods Biomech Engin 2006;9:257-70.

[5]. Simsek B, Erkmen E, Yilmaz D, Eser A. Effects of different inter-implant distances on the stress distribution around endosseous implants in posterior mandible: a 3D finite element analysis .Med Eng Phys 2006;28:199-213.

[6]. Eppley BL: Use of resorbable plates and screws in pediatricfacial fractures. J Oral Maxillofac Surg 2005; 63: 385–391.

[7]. Kim YK, Kim SG: Treatment of mandible fractures using bioabsorbable plates. Plast Reconstr Surg 2002; 110: 25–31.

[8]. Ellis E, Moos KF, EL-Attar A. Ten years of mandibular fractures: An analysis of 2137 patients. J Oral Surg 1985:59:120-129.

[9]. Abbas I, Ali K, Mirza YB. Spectrum of mandibular fractures at a tertiary care dental hospital in Lahore. J Ayub Med Coll Abbottabad 2003; 15(2): 12-4.

[10]. Sugiura T, Horiuchi K, Yoshioka M, Sugimura S, Tsutsumi S:Direct in vitro Strain measurement of miniplates during mandibular osteogenesis. Nihon Rinsho Biomechanics gakkaishi 1998; 19: 347–351 (in Japanese)

[11]. Haug RH, Peterson GP, Goltz M: A biomechanical evaluation of mandibular condyle fracture plating techniques. J Oral Maxillofac Surg 2002; 60: 73–80.

[12]. Rilo B, Fernandez J, Da Silva L, Martinez Insua A, Santana U: Frontal-plane lateral border movements and chewing cycle characteristics. J Oral Rehabil 2001; 28: 930–936.

[13]. Cox T, Kohn MW, Impelluso T: Computerized analysis of resorbable polymer plates and screws for the rigid fixation of mandibular angle fractures. J Oral Maxillofacial Surg 2003; 61:481–487.

[14]. Analysis of complications in fractures of mandibular angle .A study with FEM. J .craniomaxillofac surg 2003; 31:290-295.
[15]. Wagner A, Krach W, Schicho K, Undt G, Ploder O, Ewers R: A 3-dimensional finite-element analysis investigating the biomechanical behavior of the mandible and plate osteosynthesis in cases of fractures of the condylar process. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002; 94: 678–686.
[16]. Cawood JI. Small plateBosteosynthesis of mandibular fractures. Br J Ora l Maxillofac Surg 1985;23:79-91.
[17]. Application of finite element analysis in dentistry; Ming-Lun Hsu and Chih-Ling Chang Department of Dentistry, National Yang-Ming University Taipei, Taiwan