INTRODUCTION

A typical traumatic injury of the mandible is a subcondylar fracture. These fractures are reduced and fixated with orthopedic implants and screws. There are several implant designs available today and are driven by two main factors. First, the geometry of the implant must be small enough to fit with the limited approach due to the proximity to the temporal mandibular joint, which has promoted a minimally invasive approach. Second, the implant must support the typical biomechanical loads on the mandible during healing while maintaining contact at the fracture. This study looks at the stresses on the mandible and the implant due to biomechanical loads caused by muscles of mastication and the contact pressure at the fracture using Finite Element Analysis. Several scenarios of biting locations and implant designs are compared.

MATERIALS AND METHODS:

The mandible geometry was imported from IGES surface and represented as a solid model in Pro/ENGINEER Wildfire 2.0. This allowed for the constructs to be created by building assemblies and removing material where the screws intersected the mandible. Four scenarios were compared by performing a structural analysis using ANSYS Workbench, version 11.0.

1. Mandible, intact
2. Mandible with fracture and a “Ladder Plate” implant
3. Mandible with fracture and a “Trapezoidal Plate” implant
4. Mandible with fracture and a “Straight Plate” implant

In all cases, the boundary conditions were applied to simulate the degrees of freedom in the TMJ as constraints and muscles of mastication as loads. The loads due to the muscles of mastication were determined from mandible biomechanics literature. A surface patch in the left molar area was constrained to represent the bite location. Figure 1 depicts the boundary conditions as seen from a lateral view.

Contact was defined at the fracture surfaces. Maximum principal stresses, total deformation, and contact pressure at the fracture were compared.

In addition, the bite location was varied for the “Ladder Plate” analysis. The bite location was changed from left molar to incisor and right molar.

RESULTS:

The maximum principal stresses for each design is shown in Figure 2. The stress range was normalized to show a qualitative visual difference in the fringe plots. Figure 3 shows the contact pressure at the fracture surfaces. The pressure range was also normalized to show qualitative differences. Figure 4 shows how the stresses in the ladder plate varied as the bite location changed.

DISCUSSION:

Based on the stress results, the “Ladder Plate” is able to support the loads due to mastication with the least amount of implant stress. The contact stresses at the fracture surface are more evenly distributed for better bone healing. FEA is a valuable tool to gain insight into the biomechanics of mandible fracture fixation. The bite location varies the stresses in the implant with the incisal location being the worst. Different implant designs can be compared and optimized based on the expected loading due to biomechanics.