

Optimization of Treatment for Fractured Clavicle Bone using Finite Element Analysis

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Abstract

The clavicle bone is the only long bone in the body that lies horizontally. The method used by surgeons for treatment of clavicle bone fractures is intramedullary nailing, hook plate, Kirschner wire and plate fixation method. In intramedullary nailing a specially designed metal rod is inserted into the marrow canal of the clavicle. The rod passes across the fracture to keep it in position. It is screwed to the bone at both ends. This keeps the nail and the bone in proper position during healing. In plate fixation method a plate is used as fixing medium as the fractured bone is screwed to the plate firmly which holds the bone in desired position for healing. The metal rod and plate come in various lengths and diameters to fit most clavicle bones. Therefore need for doing to find more feasible method for treatment of clavicle bone with providing maximum strength possible to the bone in fractured state.

Keywords: Clavicle, Intramedullary Nailing, Plate Fixation

I. INTRODUCTION

A bone is a rigid organ that constitutes part of the vertebral skeleton. Bones support and protect the various organs of the body, produce red and white blood cells, store minerals and also enable mobility. Bone tissue is a type of dense connective tissue. Bones come in a variety of shapes and sizes and have a complex internal and external structure. They are lightweight yet strong and hard, and serve multiple functions. Mineralized osseous tissue or bone tissue is of two types– cortical and cancellous and gives it rigidity and a coral-like three-dimensional internal structure. Other types of tissue found in bones include marrow, endosteum, periosteum, nerves, blood vessels and cartilage.

The collarbone is a doubly curved bone that connects the arm to the trunk of the body. Located directly above the first rib it acts as a strut to keep the scapula in place so that the arm can hang freely. Medially, it articulates with the manubrium of the sternum (breastbone) at the sternoclavicular joint. At its lateral end it articulates with the acromion, a process of the scapula (shoulder blade) at the acromioclavicular joint. It has a rounded medial end and a flattened lateral end.

From the roughly pyramidal sternal end, each collarbone curves laterally and anteriorly for roughly half its length. It then forms a smooth posterior curve to articulate with the acromion of the scapula. The flat acromial end of the collarbone is broader than the sternal end. The acromial end has a rough inferior surface that bears a ridge, the trapezoid line, and a small rounded projection, the conoid tubercle (above the coracoid process). These surface features are attachment sites for muscles and ligaments of the shoulder.

II. LITERATURE REVIEW

Chaithavat Ngarmukos, Vinai Parkpian, Adisorn Patradul [1] The 2 mm Kirschner wire was introduced, using an air drill and a telescoping guide, from the medial into the lateral fragment. The medial end of the wire which perforated the anterior cortex of the medial fragment was bent backwards to prevent migration into the lung or mediastinum. In cases of non union and acute fracture in which a bone gap was present, bone graft was laid around the fracture site after internal fixation.

Favre P1, Kloen P, Helfet DL, Werner CM. [2] Fixation plate positioning remains controversial in clavicle fracture reconstruction. Biomechanical studies favor a superior plate placement and clinical series report very low mechanical complications for anteroinferior plate placement. To clarify this apparent discrepancy, a biomechanical finite element analysis of the deformation mode, stress patterns, and peak stresses involved with superior and anteroinferior clavicle plate fixation was performed.

Jay Zhijian Zhao, Gopal Narwani [3] Occupant injury assessment tools are essential to research and development of advanced occupant restraint systems. Traditionally, Anthropomorphic Test Devices (ATDs) have been used in laboratories to evaluate the restraint system performance. In recent years human body models have been developed as an important tool to help assess restrained occupant injuries which could not be evaluated by the ATDs due to their biofidelic deficiencies. The human body finite element model for an average adult male reported earlier [1], was one such tool for injury analyses of the thorax, abdomen and shoulder of a belted occupant.

Rahul Sherekar, Amar Ganjare¹, Anand Pawar [4] The main focus of this paper is to develop a realistic model of the human clavicle that would respond just like a real clavicle would in an accident, independent of load direction. For this purpose the methodology of Computed tomography (CT) and the Finite element analysis (FEA) were used to create a geometrical model of clavicle. These models will eventually have dynamic loads applied to them and have the results of the finite element analysis compared to that of results from actual car crash data of individuals of similar age. This paper will solely focus on the creation of the clavicle model and the boundary conditions and variables that could affect the outcome of the simulations.

S Raymond Golish, Jason A Oliviero, Eric I Francke and Mark D Miller [5] Clavicle fractures comprise 5–10% of all skeletal fractures, and 80% of these occur in the middle-third [6]. These fractures result from a blow to the shoulder causing axial loading [7]. The standard of care is closed treatment with sling and swathe; however, recent studies have found higher rates of delayed union, nonunion, shoulder pain, and shoulder weakness with non-operative care [8]. Risk factors for poor outcome with non-operative treatment include shortening, initial displacement, fracture comminution, and age. The indications for surgery include the need for earlier functional mobilization in the patient with an isolated injury [9] in addition to open fractures and the polytraumatized patient. For operative treatment, open reduction and internal fixation with a 3.5 mm dynamic compression plate is the standard; however, intramedullary fixation is a less invasive alternative. A retrospective clinical study by Wu et al. compared plate to IM fixation for aseptic nonunions [10]. A biomechanical study by Proubasta et al. compared a 6-hole 3.5 mm dynamic compression plate to a 4.5 mm intramedullary Herbert screw [11].

III. IDENTIFIED GAPS IN THE LITERATURE

Most of the researchers have investigated the biomechanical behavior of the clavicle bone for normal condition, natural frequencies, etc. Limited work is being done on the study of the different types of fracture in clavicle bone due to load concentration. The purpose of this work is to investigate the alternative designs of the plate which is feasible and bio-compatible.

IV. PROBLEM FORMULATION

In this project the Optimization of plate is performed using FEA. It will involve changing the plate dimensions, screw dimensions and also the number of screws which could increase the strength of clavicle bone after fracture. Also, the optimization of cross section of the bone and plate is carried out to provide the best strength to weight ratio. Calculate the load bearing capacity of healthy bone and broken clavicle plate bone.

V. RESEARCH METHODOLOGY

In present study, we create the CAD model of clavicle bone. Then analysis of the healthy bone is to be done and load bearing capacity is calculated. Generate the CAD model of intramedullary nailing and plate fixation and compare the strength. Comparison of strength of clavicle bone before and after fracture by FEA. Identify the significant parameters and optimization of identified parameters.

VI. CONCLUSIONS

The ANSYS will be applied to find an optimal setting of the different treatments for clavicle bone, The result from the Analysis method chooses an optimal solution from actual loading condition. Future investigation leaves a wide scope for the researcher to study on optimization of fixation plate and intramedullary nailing using F.E.A.

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