Finite Element Analysis of Personalized Locking Clavicle Plate model

Jifeng Xu

Zhejiang Canwell Medical Co. Ltd., Jinhua, Zhejiang, 321000, China

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Abstract: The application of finite element analysis method to construct a three-dimensional model of human bones and design of medical equipment for orthopedic surgery is more precise and faster. According to the clavicle model, the clavicle locking plate model was established. The stress distribution of the finite element model of the locking plate was evaluated under bending and torsion conditions. 64-row spiral CT was used to scan the chest of young adult healthy males. The two-dimensional image data of the male clavicle was obtained. The data were analyzed by Mimics10.0 software, and the three-dimensional finite element model of clavicle was established. The CG software was used to establish the clavicle according to the clavicle model. Lock the bone plate model. The abaqus software was used to evaluate the locking plate to give a force of 200 N downward for bending and 200 N·mm for axial torsion, to simulate the force of the clavicle locking titanium plate, and further analyze the stress distribution.

1. Introduction

Clavicle fractures are common fractures in orthopedic clinical work, mainly due to direct or indirect violence, and young men are more common. Diagnosis can be confirmed based on medical history, symptoms, signs, and X-ray examination. Clavicular fractures account for about 6% of total body fractures, which can occur in all ages, especially in young adults and children. The clavicle anatomy is located between the shoulder and the sternum. It is often due to the violent hindsight of the shoulder, and then the clavicle fracture occurs. Clinical studies have shown that the clavicular fracture occurs mostly in the transition of the medial and lateral arc of the clavicle, ie, the clavicle 1/3. In the clinical work, the research team collected 8 cases of bone fracture after postoperative clavicle fracture, all occurred in the middle of the clavicular fracture. Why did the fracture of other parts of the clavicle not find the fracture of the bone plate only in the middle fracture? In order to investigate the causes of fracture of the bone plate from biomechanical aspects, the finite element analysis method of the clavicle plate was designed, and the finite element analysis of the straight plate and the “S” type bone plate was designed to explore the kind. The bone plate is more suiTable for the treatment of mid-clavicular fractures.

2. Materials and methods

Adult healthy male volunteers (acquired by the ethics committee), aged 38, underwent 64-slice spiral CT to obtain raw data. Spiral CT machine Toshiba aquilion 64-row spiral CT; Personal computer main configuration: CPU: Intel (R) Core4 (TM) i5-4200M CPU @ 2.5GHz 2.49GHz memory: 4G; graphics card: 1G; hard disk: 512G; Mimicsl0.0 software trial version - Materialise company; UG NX 7.0 software - Simens company; finite element analysis software - abaqus - Simens company meshing software - Hypermesh - altair company. Windows 8.1 Professional Edition - Operating System - Microsoft Corporation;

Adult male volunteers were selected (accepted by the ethics committee), 38 years old, formerly healthy, with no history of clavicular trauma and other medical history. Continuous CT scan of the clavicle of the experimental subject was performed with 64-row spiral CT (Toshiba). The scanning voltage was 120KV, the current was 250mA, and the bone window value was: window width -1800, window level -600, layer thickness and layer spacing were 0.5. Mm, the original image data of the male clavicle and shoulder joint is obtained, and the data is exported, backed up, and burned into a

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disc in Dicom format for use.

3. Clavicle plate model establishment

According to the direct shape of the clavicle and the S-shaped steel plate, the UG software (Simens) was used to establish the three-dimensional geometric shape of the 7-hole clavicle locking titanium plate, processed into a stp format file, and the obtained Stp format file was imported into the Hypermesh software to apply the mesh division function. After meshing, it is exported and saved as Inp format, and further generates a three-dimensional finite element model of 7-hole straight line and S-type locking bone plate.

Figure 1 Three-dimensional finite element model of a straight locking bone plate

The three-dimensional finite element model (Inp file format) of the locked clavicle titanium plate was subjected to post-treatment of stress, bending and torsion using Abaqus software. The boundary parameters are defined according to the finite element model (straight, S-type) of the 7-hole clavicle locking titanium plate. The clavicle titanium plate model can be forced in six directions on the X, Y, and Z axes, the X axis is the parallel titanium plate axis direction, the Y axis and the Z axis are the vertical titanium plate axis direction, wherein the Y axis is the up and down direction, the Z axis For the anterior-posterior direction, according to the anatomical characteristics of the clavicle, and to distinguish the actual force of the clavicle locking titanium plate, the force is analyzed from the X, Y and Z axes respectively. The finite element analysis has certain limitations. This topic is to analyze the force of locking the titanium plate under the ideal state after the interference factor is excluded. The finite element model of the titanium plate is fixed by the proximal constraint and the mechanical compression of the distal end. According to the force of the human clavicle, the design loading force, bending force and torsion force are the same, both set to 200N, and the ultimate force of 500N is applied as a control, and the stress distribution diagram under various stress conditions is obtained.

4. Results analysis

The finite element model of the locking clavicle straight reconstruction titanium plate was simulated. The three holes at the far and near ends were screwed into the screw, the middle hole was placed, and the proximal end was fixed. The distal end was applied with a force of 200 N in the direction of the long axis of the vertical titanium plate. The stress is concentrated in the middle of the titanium plate, that is, the middle hole and the surrounding (the fourth hole). During the actual operation of the hole, the sputum is placed at the fracture end of the clavicle fracture, so the stress and strain concentration overlap with the maximum fracture stress. Under the action of external force, it is easy to cause broken plates.

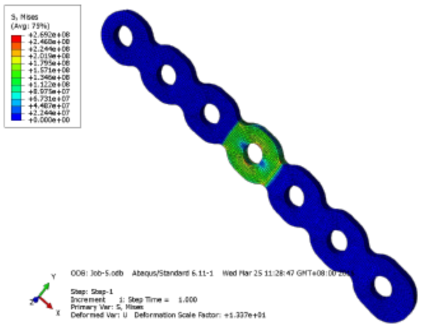

Figure 2 Straight plate bending stress distribution

The clavicle is located in the front upper part of the chest. It is the only bony structure in which the upper limb is connected to the trunk. It is located under the skin and is prone to fracture when direct or indirect violence occurs. Clavicular fractures are common in clinical practice, accounting for 5% to 10% of fractures in various parts of the body. Among them, 70% to 80% of clavicle fractures are located in the middle third of the clavicle. In the treatment of clavicle fracture, non-surgical treatment is usually used when there is no obvious displacement of the fracture end. Surgical treatment is often used for the fracture of the clavicle with obvious displacement, instability of the fracture end or combined with peripheral blood vessels and nerve injury. The main mechanism of injury to the clavicle fracture is as follows: 1. The direct violent impact on the clavicle; 2. When external violence acts on the shoulder, the force transmission acts on the clavicle, and the indirect violence leads to the clavicle fracture. According to previous statistics, it is found that clavicle fractures often have fractures in other surrounding areas, and the condition is heavier, which may be related to high-energy violent injuries. For the clavicular fractures with obvious displacement, unsTable fracture and combined peripheral nerve and vascular injury, the surgical method of open reduction and titanium plate screw fixation is gradually recognized. The classification of clavicle fractures is various, such as transverse shape, oblique shape, comminuted fracture, etc. In order to improve the feasibility of this experiment and avoid the influence factors of various types of fracture on titanium plate, this topic mainly considers the incidence rate. A high mid-clavicular fracture was used as a reference model. The biomechanical study by Robertson et al. shows that the locking titanium plate is more effective than the ordinary titanium plate in carrying the fatigue stress and the torsion resistance is better. Especially for patients with poor bone quality or osteoporosis, the use of locking titanium plates can give full play to its advantages. In recent years, there have been reports in the literature that reconstruction of titanium plate placement for the treatment of clavicular fractures has a certain biomechanical advantage over the anterior placement under torsional and bending loads. Therefore, the titanium plates used in this experiment are all locking bone plates, which simulate the condition of the bone plate in the operation of clavicle fracture.

The finite element method (FEM), also known as the finite element method (FEM), is currently more common in the field of mechanics. This calculation method was applied in the 1940s, and it was mainly applied to engineering mechanics in the early stage. In recent years, electronic computer technology has developed rapidly, and this calculation method has also been widely promoted. This calculation method is a product that combines mathematical applications, mechanical analysis, and electronic computers. Finite element analysis is a practical and effective analysis method in recent years. It uses the established three-dimensional model to analyze the distribution of stress under external force, simulate real objects, and use the data to geometrically deform and load the object. , material characteristics, one by one analysis and description. The model is divided into a number of finite elements, and the finite elements are connected by nodes to further form a combined body to replace the original objects. Then, the computer software is used to process the experimental data, and the force of each unit is analyzed from the mechanical point of view, thereby obtaining the overall mechanics of the research object. characteristic. This method was originally used as a mechanical method for research engineering and is widely used in the medical field, such as orthopedics, neurosurgery, and stomatology. The application of finite element analysis is accompanied by the rapid development and advancement of computer technology, and it is more perfect. It is more conducive to the calculation of experimental data. The computer generates various organ models of human body. The advantages of this method are as follows: (1) Due to the application of computer for data analysis, and to establish a model, it is more economical and practical. (2) The established finite element three-dimensional model has high realism, can accurately express various complex shapes, and is also accurate in material simulation. (3) Not only can the visual analysis of the physical object be performed intuitively, but also the qualitative analysis. (4) The finite element model can be reused and has good operability. The purpose of constructing the finite element model of clavicle is to use the accuracy and simulation of the model to carry out biomechanical finite element analysis, and to provide a more reliable theoretical basis for the simulation of clavicular fracture internal fixation and the placement of internal fixation. However, in this process, in order to ensure the feasibility of the experiment, it is necessary to simplify the design of the model. In addition, the three-dimensional finite element model obtained from the experiment is verified to be closer to the real situation, so that it can be in clinical practice. application. In this experiment, 64-slice spiral CT was used to scan the clavicle of normal individuals.

5. Conclusion

According to the original data obtained by CT scan, the clavicle model is constructed, and then the three-dimensional model of the clavicle titanium plate is constructed. The fit to the clavicle is good, and the three-dimensional printing can be performed according to the model to obtain a personalized bone for a single individual. Plate, the concentrated part of the stress of the plate was obtained by finite element analysis. Through the finite element analysis of the two kinds of clavicle plates, the maximum stress distribution of the 7-hole titanium plate is located in the center of the center hole under the lateral bending and axial torsion. In the actual operation, there is a superposition of stress in the middle of the clavicle fracture end and the locking hole of the dislocation. If the titanium plate is placed to avoid the stress concentration, the finite element analysis is used to guide the placement of the bone plate during the operation. To achieve the purpose of dispersing the stress on the bone plate as much as possible, it can avoid the occurrence of postoperative fracture, and provide theoretical guidance for clinical practice.

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