FINITE ELEMENT SIMULATION OF THREE SURGICAL TREATMENTS OF DISTAL RADIUS INTRA-ARTICULAR FRACTURE

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ABSTRACT

Distal radius fractures are the most common injuries, with an estimate overall crude incidence of 36.6/10,000 person-year in women and 8.9/10,000 person years in men. Assuming a continuous rise in the incidence of distal radius fractures with age, and based on the fact that older population continues to grow, incidence of distal radius fractures can be expected to increase. Different surgical methods can be used to fix the complicated, unstable and displaced distal radius fractures. The conventional surgical method with volar plating has been described the good results in young patient. However, the elderly patients especially who has the osteoporotic bone may have higher risk of loss of reduction in conventional types of fixation. The aim of this study is to compare the latest treatment angle-stable constructs with conventional model for unstable three fragmental intar-articular distal radius fracture (AO 23-C2.1) under various load conditions using finite element analysis in order to find the stiffer surgical methods to facilitate the anatomic reduction and maintenance of the reduction. The fixation methods consist of 1 I-shape styloid plate and 1 intermediate dorsal plate (Group 1), single T-shape volar plate (Group 2) and 1 I-shape styloid plate and single T-shape volar plate (Group 3). This study analysed the rigidity base on linear load-displacement graph. To compare the rigidity, the fixation methods analysed under the applied loads (axial-loads, bending and torsion). The displacement and von Mises stress values showed the superior stability and rigidity for angle-stable double plates constructs.

ABSTRAKT

Tulang yang patah pada bahagian distal radius adalah kecederaan yang paling umum, dengan anggaran kasar secara keseluruhan sebanyak 36.6 bagi setiap 10, 000 orang (perempuan) dan 8.9 bagi setiap 10 000 orang (lelaki) setiap tahun. Pertambahan kes dijangka akan terus berlaku lantaran wujudnya pertambahan warga tua (berikutan peningkatan taraf kesihatan) yang pastinya lebih terdedah kepada kecederaan tulang, Terdapat banyak kaedah yang boleh digunakan bagi merawat masalah kepatahan tulang radius distal Kaedah pembedahan konvensional dengan menggunakan plat pada bahagian volar telah memberi impak yang baik pada pesakit muda tetapi tidak kepada pesakit tua, terutama yang menghidap penyakit osteoporosis. Tujuan kajian ini adalah untuk membuat perbandingan antara kaedah terbaru iaitu sudut-stabil baru konstruk dengan model konvensional bagi merawat kes kepatahan tulang bercirikan 'unstable three fragmental intar-articular distal radius fracture' (AO 23-C 2.1). Analisis ini menggunakan kaedah simulasi komputer dengan menggunakan 'Finite element ' bertujuan mencari kaedah terbaik dalam mennghasilkan kaedah fiksasi yang lebih kukuh. Terdapat tiga kumpulan utama bagi kaedah fiksasi, iaitu penggunaan satu plat styloid berbentuk I dan satu plat pada bahagian pertengahan dorsal (Kumpulan 1), penggunaan satu plat di bahagian volar berbentuk T (Kumpulan 2) dan penggunaan satu plat berbentuk I pada bahagian styloid dan satu plat berbentuk T pada bahagian volar (Kumpulan 3). Analisa ke atas kekukuhan struktur dibuat berdasarkan graf beban-perpindahan linier. Bagi tujuan itu, kaedah fiksasi dikaji dengan menggunakan keadaan beban yang pelbagai (paksi-beban, lentur dan torsi). Hasil daripada kajian ini (berdasarkan nilai tekanan von Mises dan juga perubahan bentuk) menunjukkan bahawa plat ganda sudut-stabil pembinaan yang menggunakan dua plat adalah lebih baik dari segi kekukuhan struktur berbanding penggunaan hanya satu plat sahaja.

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2D	-	Two Dimensional
3D	-	Three Dimensional
CAD	-	Computer-Aided design
CT	-	Computerized Tomography
DRFs	-	Distal Radius Fractures
DP	-	Double Plating
FEA	-	Finite Element Analysis
HU	-	Hounsfield Scale
LCPS	-	Locking Compression Plate System
LCPS	-	Locking Compression Plate System
LDRS	-	Locking Distal Radius System
MDP	-	Modified Double Plating
MRI	-	Magnetic Resonance Imager

CHAPTER 1

INTRODUCTION

1.1 Wrist joint

Wrist joint is the most complex of all joints in the body. The wrist must be extremely mobile to give our hands a full range of motion. At the same time, the wrist must provide the strength for heavy gripping. The kinematics and kinetics of the wrist hasn’t been completely understood yet. The wrist joint plays a significant role in maintaining a normal daily life. Normal wrist motions involve with the ligaments as well as the carpal, radius and ulna bones [1].

1.1.1 Wrist anatomy

Wrist structure can be divided in to several categories:

- bones and joints
- ligaments and tendons
- muscles
- nerves
- blood vessels

1.1.1.1 Bones and joints

The connections from the end of the forearm to the hand there are 15 bones. The wrist itself contains 8 bones, called carpal bones, the ulna and the radius. The carpal bones are separated into two rows, namely the proximal and distal that shown in Fig1.1.

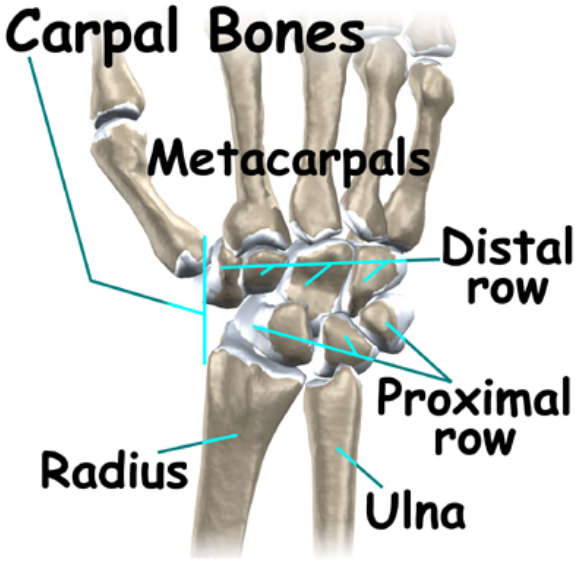

Fig 1.1: Distal and proximal rows of carpal bones.

The wrist joint comprises into three different parts, the radiocarpal joint, intercarpal joint and the distal radioulnar joint. Most of the movements of the wrist occurs at the radiocarpal joint, which is a synovial articulation composed by distal end of the radius and the scaphoid, lunate and triquetrum bones [2].

1.2 Wrist fracture

Wrist fractures are kind of fractures that happen any of carpal bones and two forearm bones (radius and ulna). The most commonly wrist fractures are distal radius and scaphoid fractures.

1.2.1 Distal radius fracture

Comminuted fractures of distal end of the radius are caused by high-energy trauma and present as shear and impacted fractures of the articular surface of the distal radius with displacement of the fragments. The position of the hand and the carpal bone and also the impact of the forces cause the articular fragmentation and the displacement. Distal radius fractures are very common. In fact, the radius is the most commonly broken bone in the arm. The break usually happens when a fall causes someone to land on their outstretched hands. It can also happen in a car accident, a bike accident, a skiing accident, and similar situations [3].

1.3 Problem Statement

Distal radius fractures are among the most common injuries, with an estimate overall crude incidence of 36.6/10,000 person-years in women and 8.9/10,000 person-years in men. Assuming a continuous rise in the incidence of distal radial fractures with age, and based on the fact that older population continues to grow, incidence of distal radius fractures can be expected to increase. To allow for good functional outcome following unstable distal radius fractures, restoration of both the radiocarpal and the radioulnar relationship is essential, therefore surgical treatment should facilitate for anatomic reduction and maintenance of the reduction. It means different surgical methods can be used to fix the complicated, unstable and displaced distal radius fractures.

The conventional volar plating for treated the dorsal displaced distal radius fractures has been described with good results in young patients and with a mix of fracture complexity. However, elderly patients with osteoporotic bone may have higher risk of loss of reduction in conventional types of fixation because of screw loosening and because of the toggle effect of the screws within the distal part of the plate. Therefore the necessity of an optimum technique for restore not only the anatomical alignment of the wrist but also its proper biomechanics such as preventing re-displacement of the fragments and re-establishing the normal wrist load transmission pattern has been provided new studies.

1.4 Objective of study

The objective summery of this study included:

1) Simulation of the distal part of the wrist and also simulation the intra-articular distal radius fracture (AO 23-C2.1).
2) To develop 3D model of the fractured bone for all types of fixation methods.
3) To simulate various surgical treatments for this type of intra-articular fracture.
4) To compare between all different types of surgical treatments for fracture fixation of the distal radius.

1.5 Scope of study

The scope the study, to simulate the 3D model of radius bone and also simulated the unstable intra-articular fracture on bone. The next step to find the surgical methods for this kind of distal radius fracture and simulated these surgical method as same as the real plates of fixations. Then according to surgical open reduction and internal fixation should find the optimum positioning for all types of fixations on fractured bone. To provide the valid analysis should find the best positions for boundary condition and exerting the loads. Should mention that the loads values should be choose base on the daily motions that fractured wrist faces. Finally, should compare the results of all types of fixation under the loads and find the most stabile and rigidness of fixation method.