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# THE KINEMATIC, DYNAMIC AND FEA ANALYSIS OF THE HUMAN MAIN JOINTS

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**ABSTRACT**
*The elbow and knee are important joints of the human skeleton and they are composed by bones, ligaments, tendons and cartilages. From such reason, scientifically studies are very difficult to realize, almost they are made in a statically system. First, to understand the problems, which appear in these joints, it is very important to know the anatomy of the human articulations and the way in which the components are working together to realize a normal functionality.*
*This paper presents a study method for the human joints and the necessary steps in order to obtain virtual joints, kinematic, dynamic and FEA simulation. For this purpose it was used a CAD parametric software which permits to define models with a high degree of difficulty. First, were defined the main bone components as femur, tibia, humerus, radius and cubitus, using tomographical images. After that operation were added the "soft" components as ligaments, tendons, menisci and muscles. The obtained model was prepared for kinematical and dynamic simulation. The input functions and parameters for the joint simulation were: the masses of the bone elements, the force applied on bones and the driver angles in the joints. Also, after the meshing operation can be obtained dynamic maps of stress, strain and displacement. These models can offer the base for different studies in normal situations (flexion-extension movement, normal walking a.s.o.) or surgical cases (fractures, meniscectomies a.s.o.). In the virtual joints can be included orthopaedic implants and prosthesis and the simulation can give important information about the behavior of the components of the joint.*
**Keywords:** knee, elbow, simulation

## 1. INTRODUCTION

### 1.1. Elbow joint

The research theme, presented in this paper, it was a part of a large subject of study, which attracts the knowledge from different research fields. The subject of this paper permits the cooperation between many researchers which activate in different fields and which have the capacity to develop informational methods to solve difficult problems given by the complexity of the pathological and normal situations.
The elbow is an important joint from the human skeleton and it is composed of bones, ligaments, tendons and cartilages. From such reason, scientifically studies are very difficult to realize because the elbow is one of the most complex joint in the human body, almost they are made in a statically system [2, 3].
First, to understand the problems, which appear in this joint, it is very important to know the anatomy of the elbow, the components of that joint and the normal functionality of these parts.

A humerus fracture is an injury to the bone of the upper arm. The upper arm bone, the humerus, connects the shoulder to the elbow. Humerus fractures are generally divided into three types of injuries:
- Proximal humerus fractures occur near the shoulder joint. The shoulder joint is a ball-and-socket joint, with the ball being the top of the humerus bone. Fractures of this ball are considered proximal humerus fractures. These fractures may involve the insertion of the important rotation cuff tendons. Because these tendons are important to shoulder motion, treatment may depend of the position of these tendon insertions.
- Mid-shaft humerus fractures occur away from the shoulder and elbow joints. Most humeral shaft fractures will heal without surgery, but there are some situations that require surgical intervention. These injuries are commonly associated with injury to one of the large nerves in the arm, called the radial nerve. Injury to this nerve may cause symptoms in the wrist and hand.
- Distal humerus fractures are uncommon injuries for adults. These fractures occur near the elbow joint. These fractures most often require surgical treatment unless the bones are held in proper position.
Humerus fractures are commonly seen in the acute care setting and make up 5% of all fractures. The most common cause of proximal humeral fractures is the fall from standing, followed by motor vehicle accident and a fall involving stairs. Additional mechanisms include violent muscle contractions from seizure activity, electrical shock, and athletic-related trauma. Proximal humeral fractures are most often closed. Humeral diaphyseal fractures causes include a fall from standing, vehicle accident, a fall from height, and pathological.

### 1.2. Knee joint

The subject of this paper permits the cooperation between many researchers which activate in different fields and which have the capacity to develop methods and techniques to solve difficult problems given by the complexity of the scientifically target [6].
The knee joint is an important joint from the human locomotion system and it is composed of bones, ligaments, tendons and cartilages. From such reason, scientifically studies are very difficult to realize because the knee is the most complex joint in the human body, almost they are made in a statically system.
To understand the problems, which appear in this joint, it is very important to know the anatomy of the knee and the way in which the components are working together to realize a normal functionality.
The knee has ligaments, tendons, bones, menisci and cartilages like the main components.

## 2. THE VIRTUAL MODELS OF THE BONE COMPONENTS OF THE JOINTS

To obtain the tomographical images of the three bone components (humerus, cubitus and radius) were used two scanning schemes. First, was completed a complete scanning operation for 5 mm distances having the results 147 images. After that, had been obtaining cross section images at the distance of 1.25 mm for the ends of the bones and the elbow joint area [1]. For the femur and tibia bone were used two scanning schemes at 1 and 3 mm (Figure 1).

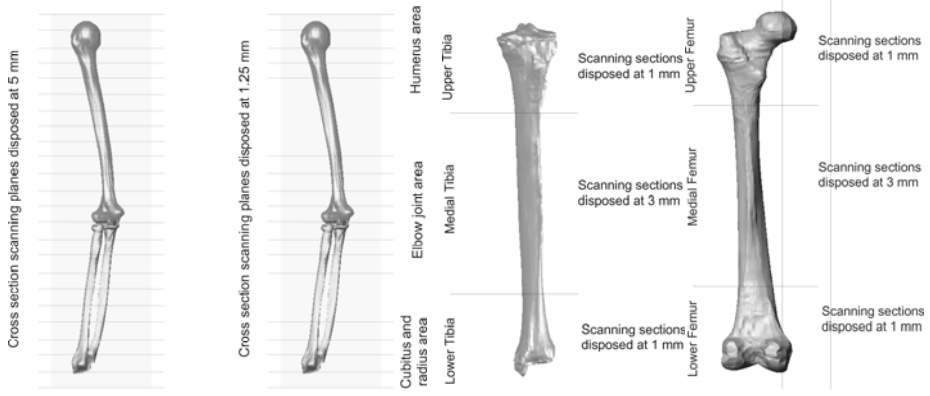


*Figure 1. Main tomographical schemes for the bones of the two joints.*

The results (tomographical images were organized and analized. In Figure 2 were presented some tomographical images of the main bones.

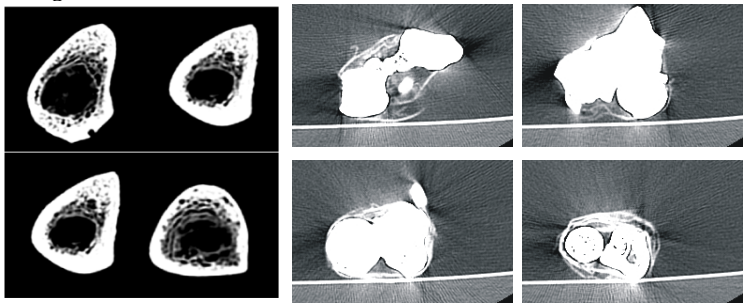

*Figure 2. Main tomographical images for tibia and elbow joints.*

The sections obtained after the scanning operation were re-drawn in a parametrical sofware were were obtained the virtual models for the components of these joints. Also, using the anatomical angles and positions, these joints were assemblied in two virtual bio-mechanical systems (Figure 3).

*Figure 3.Virtual components and the two bio-mechanical analized systems.*

## 3. THE SIMULATION RESULTS

Using different work hypothesis were obtained the simualtion results as simulation movies, tables of results, stress, displacement and strain maps (Figure 4).

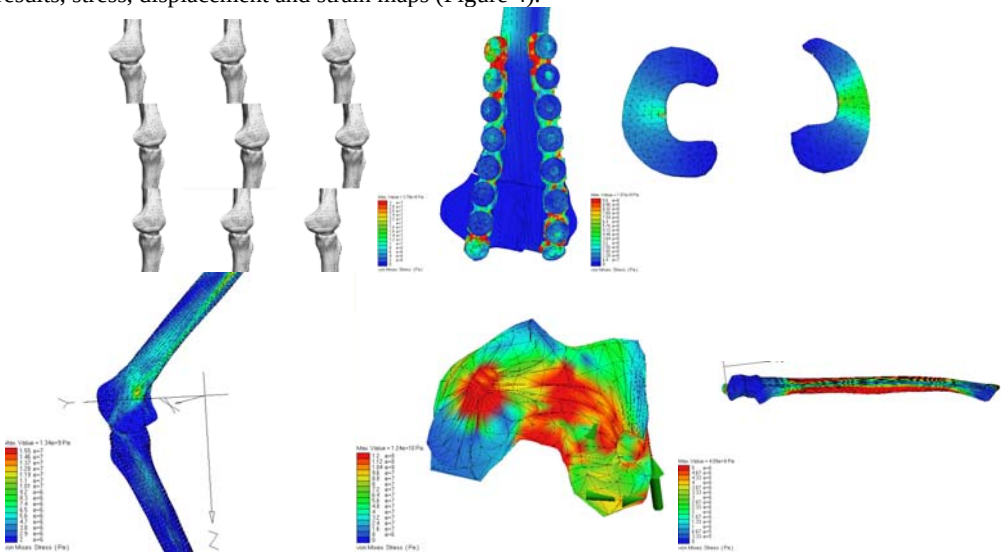

*Figure 4.Virtual components and the two bio-mechanical analized systems.*

## 4. THE CONCLUSIONS

The elbow is one of the most complex joint from the human body, but this paper proves the mechanical studies can be made starting from anatomical knowledges. The behavior of the virtual elbow can give the important informations which can be used in the fields of robotics, medicine sciences and medical robotics [2,3]. Also, on the virtual elbow joint can be attached virtual prosthetic elements for virtual post-surgery simulations [5,8].

The obtained models were completed with the mass properties and the virtual bones had in that moment the same inertial characteristics as the real bones.

Additionally, can be obtained different comparing diagrams for analysis and disscusions.

Also, on the virtual knee joint can be attached virtual prosthetic elements for virtual post-surgery simulations. The simulation program permits the obtaining of some kinematical, statically or dynamical results in a short time with a high precision. Thus, it can obtain the position, velocity and acceleration variation (in time) for any biomechanical system. In the studied case, these variations permit the obtaining of other important function parameters [3,4,7].

It can be obtained the forces in joints, which could require an ample calculus or special equipment, permit the obtaining of some important parameters, which define the entire kinematical behavior. These programs offer important databases for analysis with finite element or processing simulation programs. The utilization of these programs is easy and, starting from a three-dimensional CAD model, permit the rapid obtaining of some results, which, usually, could require complex and expensive equipment. In conclusion, the virtual bones that we studied can be used as prototype model for the studies regarding elbow and knee bones fractures with application in medical researches.

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