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Modeling by Photoelasticity with Applications in Biomechanics

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Abstract

This paper presents experimental models that can be used in biomechanical field, such as the analysis of the tension in a necrosed femur. In this case there are used physical models other than the original systems. Information obtained from experimental determinations lead to the adoption of solutions that optimize medical treatment.

Key words: *stress, strain, ultimate state, fissure, drilling, necrosis, femur*

Introduction

Drilling decompression therapy is a procedure used to treat aseptic necrosis of the femoral head. The principle is relatively simple, using a drill is performed one or more wells in the proximal third of the femur.

Its role is to reduce the pressure inside the femoral head and to promote blood circulation at this level. Discontinue this vicious circle by reducing hiperpresiunii pathophysiological bone marrow and results in immediate disappearance of pain, improved venous drainage congestion decreases necrotic tissue and promote revascularization by complex area.

The principle of this method of treatment is based on reducing spinal pressure, possibly even stop evolving or reversibility of the process.

The effect is similar to drilling for suffering nerve decompression tunnel syndrome or the muscle compartment syndromes. In osteonecrosis the cycle is interrupted even by reducing hiperpresiunii medullary origin and results in immediate disappearance of pain, improved venous drainage congestion decreases necrotic tissue and promote revascularization by complex area.

The aim is to achieve mechanical decompression of the affected area to stimulate angiogenic response in drilling channels, promote venous drainage and promote bone neoformation the necrotic area, with the final effect preventing collapse. As decompression method was proposed drilling of oriented multiple layers of the femoral head subchondral process that reduces high pressure and bone marrow while providing channels for vessels entering neoformation.

Starting from this observation we wanted to determine whether bone loading behavior is different or not from a drilling or drilling more wells and to what extent these changes bone strength. Drilling is also very important place in subsequent behavior of all results.

The model serves not only to verify the analytical solutions, and to find new ways of developing theory. Loads applied models had the same nature as the forces that may require human bone.

Drilling decompression is a relatively simple solution treatment, with satisfactory results if completed early stage avascular necrosis of the femoral head. Success is ensured by the location and extent of necrosis as them. In this paper determined as proximal third femoral when it is loaded, and drilling without decompression.

To this end it has two methods to determine the changes produced by drilling decompression in the structure of bone strength.Behavior of the upper third of the femur with and without direct drilling was analyzed using a machine model Galdabini and indirectly tried using the photoelasticity method.

Behavior of Femur by Direct Method

There are several ways to charge third proximal femoral: axial and abduction required. It shows only the proximal third femoral axial load. We used five human femurs were cut at the top of the line 30mm harsh. Behavior was analyzed only the upper third of the femur. These were introduced in some thump that bone diameter. Free the remaining space between sleeve and bone was filled with soft gypsum.

Models thus prepared were mounted on the test machine Galdabini. Of the five femurs, four were drilled with drills having dimensions of 3.2 mm and 6 mm, and the number of wells ranged from one to four.

Charging is done on the upper anterior third of the femoral head similar to physiological bone loading. Loading force was increased gradually. Work With Graph 2.0 software were acquired and interpreted data and then load forces, stresses and deformations. Compressive force applied to the femoral head was increased progressively to break bone (fig. 1).

Fig.1. Broken femur

Loading femur on the machine to try to bring useful information on the applied compressive behavior of bone. Following this experiment resulted in such findings point because no two identical femurs or repeated test conditions not identified.

These issues were confirmed by the results of the tests. Forces which femur models have yielded values between 3.5 kN and 7kN.

Proximal Third Femoral Loading Behavior, Determined by Using Photoelasticity

Loads applied models had the same nature as the forces that may require human bone. Surface forces were applied mechanical model by satisfying the following conditions: reproduce without any change in such real tasks to perform loading speed enforcement tasks separately or simultaneously during deformation model, the applied forces do not change or additional forces arise, each load can be measured.

The main components of load devices are: frame structure type resistance elements and applying forces on the model. Depending on the purpose were adopted solutions that will shape the best actual loading condition.

Geometric shape photoelastic model is identical to a longitudinal slice obtained by cutting the femoral proximal third.

The model was obtained by machining a plate 6mm thick cast resin polymerization of optically active (dinox), in a specially constructed matrix.

From the same batch were made: samples for determination of modulus of elasticity and more the form of a disk 60 mm in diameter for determining photoelastic constant, all with thickness of 6 mm.

The study was conducted on geometrically identical models but with different reports between resin and hardener. The photoelastic material behaves similar to steel in the elastic range. After establishing a plan routes defined drainage holes with a 3mm diameter diamond drill and appropriate cutting regime, taking care not to create tension during processing.

Photoelastic models were studied using a polariscop plan and the images were recorded.

To illustrate the method of determining the variation of stress photoelasticity of healthy bone, necrosis and then the treatment options are the most suggestive cases by viewing field of tension.

A first analysis refers to a healthy bone, cartilage integrity, the hip joint without pathological changes. Tension is represented in Figure 2.

Another example (fig. 3) is the representation of a vascular necrosis of the femoral head cartilage contact the point of contact integrity and external supero region of the femoral head (cartilage destruction). There is an overload of the base of the femoral neck.

In the following figures, we present just a few possible scenarios of drilling models:

- Single borehole diameter 3 mm to the top of necrosis (fig. 4);
- Model with two drilling leaving from the same point and ends including necrotic area (top and bottom) in the upper neck tensions (fig. 5);
- Model with four wells and four external cortical input (fig. 6). Drilling in the femoral neck intersects the maximum voltage occurs at the femoral neck. There is a growing tension in the top of the cervix.

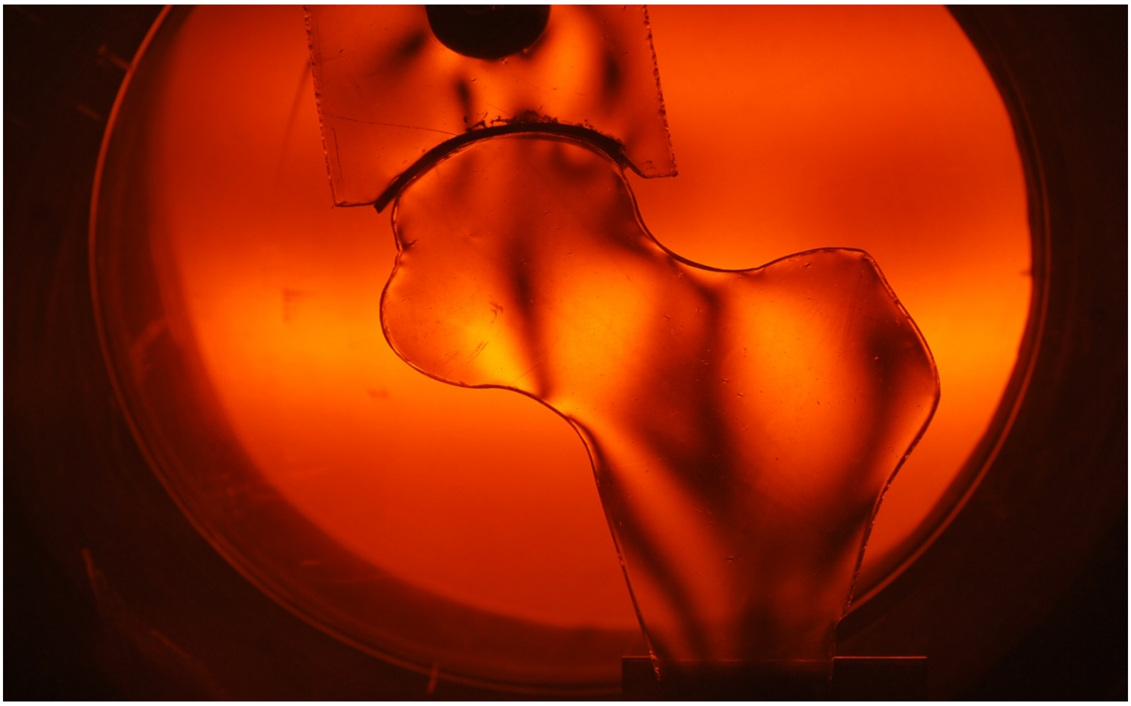

Fig. 2. Femur healthy

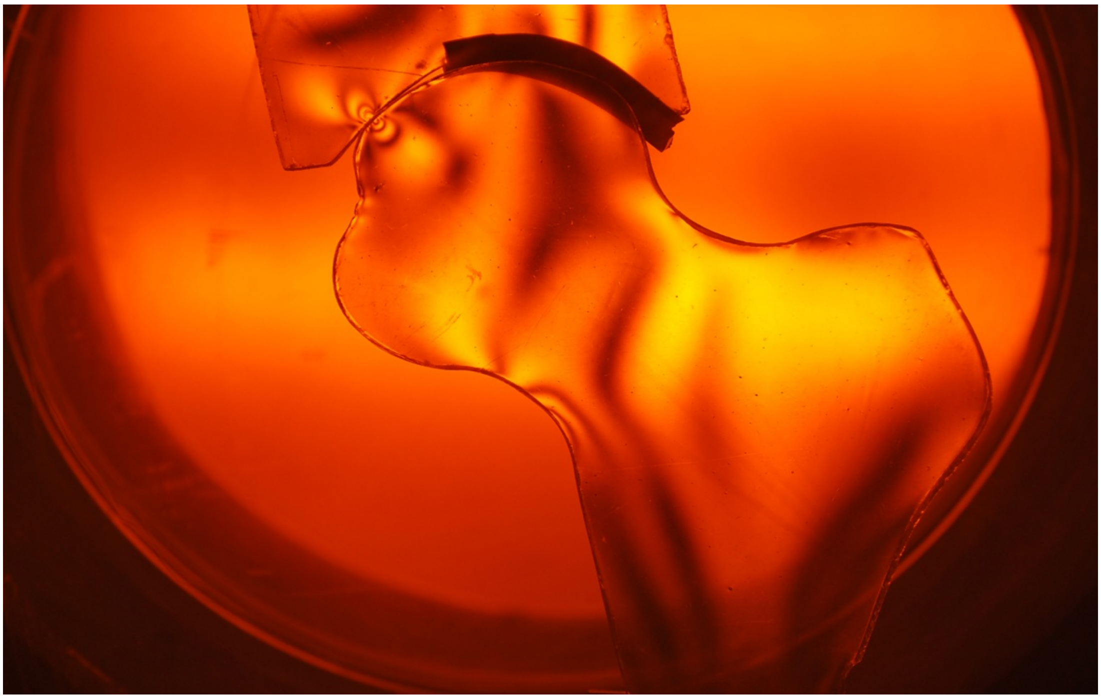

Fig. 3. Contact the cartilage integrity, and a point of contact in the region of the femoral head superexternal

Photoelastic method was used to check the route of the holes. Using this method one can determine the state of tension produced from the hip joint damage and to decrease after drilling decompression section.

From the analzsis of the iso-chromed field there can be foreseen where can the section breaks (fractures) initiate when demands are extreme. Rupture was not significantly influenced by the number and size of drilling. Interesting is to analzye the place where fracture took place. In some cases rupture occurred at the femoral neck, the other at the base of femoral neck.

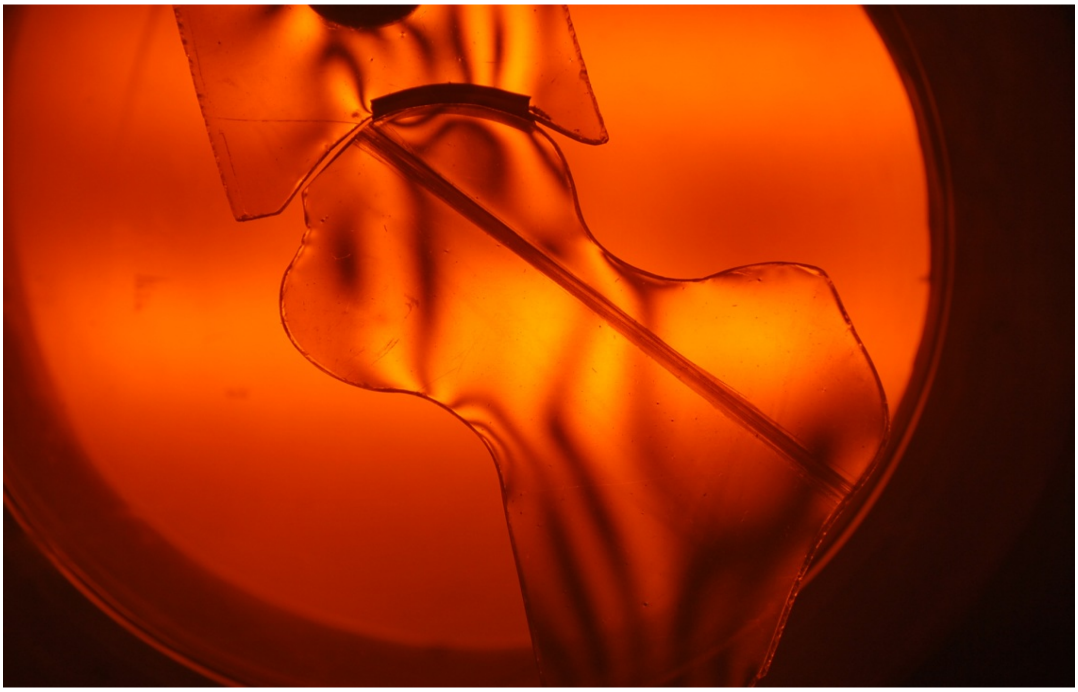

Fig. 4. Drilling unique

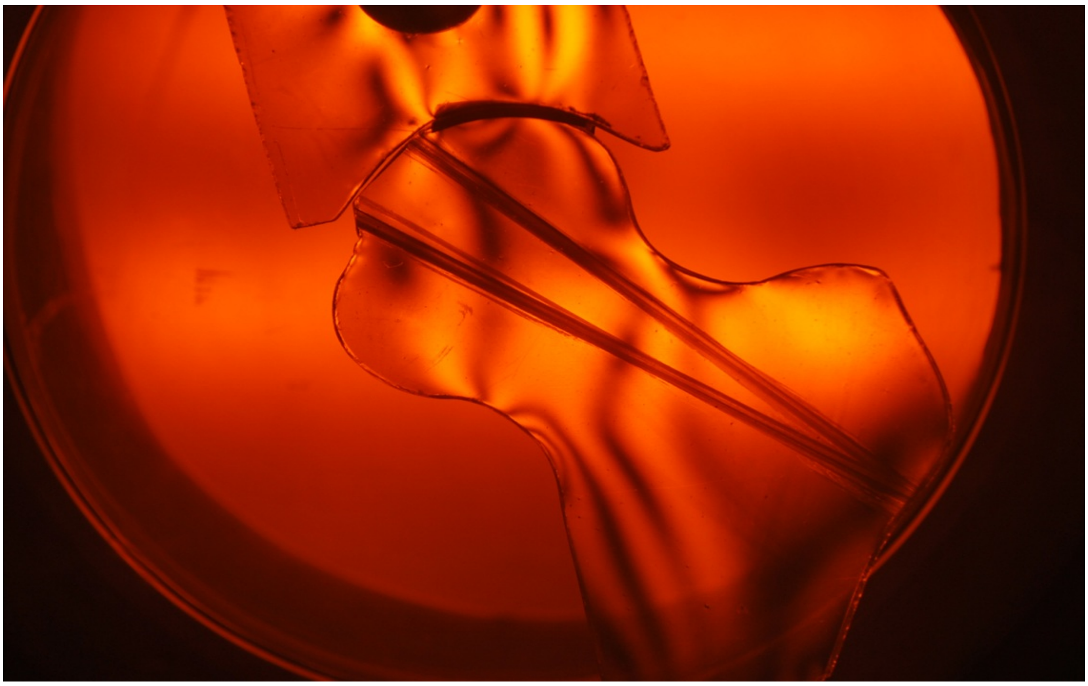

Fig. 5. Model with two wells

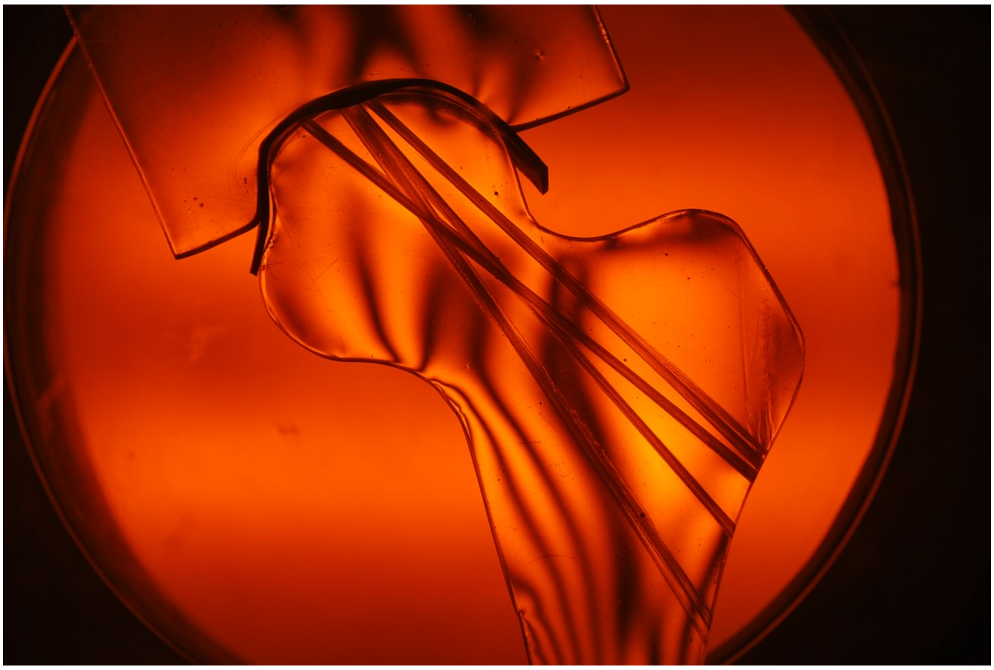

Fig. 6. Model with 4 wells

In medicine the methods of investigation are more difficult and we can reach final conclusions based only on observations.

References

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Modelarea prin fotoelasticitate cu aplicații în biomecanică

Rezumat

Lucrarea prezintă modele materiale care permit abordarea pe cale experimentală a unor probleme ce nu pot fi rezolvate prin alte metode. În cazul de față modelele sunt de altă natură fizică, decât sistemele originale. Informațiile obținute în urma determinărilor experimentale conduc la adoptarea unor soluții care optimizează tratamentul medical. Aplicațiile prezentate sunt din domeniul ortopediei.