

FINITE ELEMENT ANALYSIS OF CEMENTLESS PRESS-FIT ACETABULAR COMPONENT MEDIALISATION IN THE DYSPLASTIC HIP

PhD Thesis Abstract

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Introduction

The disease known as congenital or developmental dysplasia of the hip (DDH) encompasses a series of pathological changes of the hip joint – namely size, shape, orientation and organization abnormalities of the acetabulum and proximal femur – that can range from a simple shallowness of the acetabular cavity to a complete high hip dislocation. It has been estimated that approximately 48% of hip osteoarthritis cases that need total hip replacement show DDH-specific anomalies, making this disorder the most frequent cause of secondary osteoarthritis of the hip. Unfortunately, this is a disease that mostly afflicts patients at a younger age, thus the difficulties of hip replacement caused by altered anatomic conditions are further enhanced by the fact that most of these cases will probably need revision arthroplasties in their lifetime.

Many techniques have been developed to address hip osteoarthritis secondary to DDH, one of the most promising being medialization of the acetabular component. This method has the benefit of enabling the use of uncemented endoprosthesis components, that are better suited for these relatively young patients.

Given the complex anatomic changes of hip dysplasia, three-dimensional CT reconstructions are usually needed for a better understanding of the local conditions whilst preparing for arthroplasty. This has offered the possibility of conducting elaborate studies of different surgical techniques using experimental finite element models.

My thesis is divided into two main parts – a general part that focuses on the current state of knowledge regarding hip dysplasia, and a second part of personal studies and contributions. The theoretical general part consists of 4 chapters, presenting the most significant aspects of the etiology of hip dysplasia – **first chapter**, the imaging and diagnosis of the disease – **second chapter**, and the most widely used methods of classification – **third chapter**, while the **fourth chapter** addresses hip biomechanics in both normal conditions and in case of dysplastic changes.

The thesis's second part presents 3 personal studies, as follows: a clinical study that correlates two of the most widely used evaluation tools for assessing the results of hip arthroplasty (the Harris Hip Score and the Visual Analog Scale), a second study in which I evaluated the clinical and radiologic results of total hip replacement with the medialization of the acetabular component in dysplastic hips, and a third study using finite element modelling to analyse the stress distribution pattern at different degrees of medialization.

Objectives

In the **first study**, I wanted to correlate the Harris Hip Score (HHS) and the Visual Analog Scale (VAS) and to assess the possibility of interchanging these in evaluating the

results of total hip replacement for patients with hip dysplasia. My **second study** was designed to analyse the results of uncemented total hip replacement and the medialization technique in a clinical setting, using the classic radiologic and clinic methods of evaluation. My intention was to observe if adequate radiologic results translate into improved clinical and functional outcomes. I designed my **third study** as a means of experimentally studying the way in which the degree of medialization changes the pattern and magnitude of stresses acting on the acetabular component-bone complex, and the hemipelvis as a whole. For this I used finite element modelling and analysis on a dysplastic pelvis model that I created based on CT images, with the implantation of a hemispherical cementless press-fit cup.

Methodology

I used statistical software for descriptive statistics and to assess correlation between the studied variables, and three-dimensional reconstruction software and finite element modelling and analysis software for both creating solid models of the dysplastic hemipelvis and the acetabular component, and measuring stresses and evaluating their distribution.

Clinical study

Due to the special demographic and anatomic characteristics of patients with hip osteoarthritis secondary to DDH, their subjective evaluation of the results of surgery is especially important. The clinical study was conducted with the aim of correlating the Harris Hip Score (HHS) and the Visual Analog Scale (VAS) in the assessment of the outcomes of total hip arthroplasty in a group of patients with hip dysplasia. I also tried to evaluate whether the use of SAV could replace that of the HHS. Although I found that VAS is a much more suitable tool to evaluate patient satisfaction after hip surgery (one that is easily accepted and understood), and there is a positive correlation between the two studied instruments (correlation coefficient of +0.71, $p < 0.001$ and +0.77, $p < 0.001$, pre- and postoperatively), neither of them should be used alone. It is always best to combine both objective and subjective outcome measures for assessing the results of these surgical interventions.

Radiologic study

The second study included a number of 53 hips in 41 patients with DDH that were treated by total hip replacement with cementless endoprosthesis. In all cases the acetabular component was medialized (between 3.0 ± 2.1 mm and 6.0 ± 3.3 mm), and patients were followed up for a medium of 4 years (2 to 6 years). Outcomes were evaluated clinically (HHS) and radiologically (type of dysplasia, hip centre position, degree of medialization, protrusion of the cup beyond the Kohler line, cup coverage percentage and abduction angle, component fixation). I concluded that acetabular component medialization is a relatively easy technique that offers good mid-term results, and an adequate fixation of uncemented endoprosthesis components.

Finite element analysis

In this third study I used three-dimensional reconstruction software to obtain the 3D model of a dysplastic pelvis (based on CT images) and also a model of the cementless press-fit cup used. I then created finite element solid models of both hemipelvis and cup using specific software, and implanted the cup in the acetabulum, at different degrees of medialization. With the help of finite element analysis software, I measured the von Mises stress pattern and magnitude of stress acting on the hemipelvis and the acetabular component-bone complex, to determine the ideal degree of medialization, that offers both good fixation and load distribution.

General conclusions

Hip dysplasia is a disease that is responsible for the early development of secondary osteoarthritis at a relatively young age. Total hip arthroplasty is a difficult procedure in these cases, because of the altered anatomic conditions, but 3D reconstruction and finite element modelling can help in preparing for surgery, as well as offering a way of studying different

operative techniques. One of these techniques – medialization of the acetabular component – has proven to be a both reliable and relatively easy method of obtaining adequate fixation of a cementless press-fit component. The outcomes of total hip replacement in these patients should be evaluated objectively and subjectively, and patient-reported outcome assessment tools are beneficial for determining the degree of satisfaction after this major surgery.