ILIOPSOAS IMPINGEMENT AFTER TOTAL HIP ARTHROPLASTY - FINITE ELEMENT ANALYSIS

***Sorin Tudor Pop*, Associate Professor, MD, PhD**
***Sandor-Gyorgy Zuh*, Assistant Professor, MD, PhD**
Department of Orthopedics and Traumatology
Faculty of Medicine, UMF Tîrgu-Mureş, Romania
Margit Hidi, MD
Attila Vass, MD
Clinics of Orthopedics and Traumatology
Mureș County Clinical Hospital, Tîrgu-Mureş, Romania
***Istvan Gergely*, Lecturer, MD, PhD**
Department of Orthopedics and Traumatology
Faculty of Medicine, UMF Tîrgu-Mureş, Romania

Abstract

Aim of this paper. Is to study the iliopsoas impingement with three-dimensional modeling (3D) after total hip arthroplasty in extended position of the hip in case of 28 and 36 mm diameter prosthetic heads and the acetabular component in malposition (retroversion). **Material and methods.** We performed a 3D reconstruction of the pelvic bone, the left femur and left iliopsoas muscle of a 27 year old male based on CT images. After that we created a solid body that we used for the arthroplasty performed in the variants mentioned above and we used the finite element method for the analyses. **Results.** There were no traces of impingement with the 28 mm and 36 mm diameter femoral head, when the joint is in extension. When the acetabular component was in malposition, we found a stress aerie on the iliopsoas muscle and acetabular component meeting point. **Conclusion.** In our research, we demonstrated by 3D modeling and finite element analysis that after total hip arthroplasty using a large diameter femoral head, with the hip in extension, there is no pressure on the surface of iliopsoas muscle, contrary with the case of the acetabular component in retroversion. We can avoid this placing the acetabular component in angle of 45^o inclination and 10^o anteversion.

Keywords: Iliopsoas impingement, total hip arthroplasty, 3D modelling, finite element analysis

Introduction

Hip impingement refers to a stress phenomenon that may occur in the bone structure and soft tissue. Based on literature data findings, iliopsoas impingement occurs in 4.4% after total hip arthroplasty (Bricteux, Beguin, & Fessy, 2001). Iliopsoas impingement is caused by the hip prosthesis making contact with tendons, capsule and soft tissues including muscles, being the source of pain. The most common impingement portion is the anterior edge of the acetabulum.

There are many causes of groin pain resulting from soft tissue impingement (Heaton & Dorr, 2002), (Jasani, Richards, & Wynn-Jones, 2002) for example: psoas irritation caused by any screw used for fixation, cement extrusion, oversized acetabular component or reinforcement rings, malposition (retroversion) of the acetabular component, a large diameter femoral head (> 36mm), or the lengthening of the lower limb.

Pain is a common consequence of impingement (Dorr, Hilton, Wan, Markovich, & Bloebaum, 1996), (Trousdale, Cabanela, & Berry, 1995). When impingement occurs in the tendon, capsule, muscles inflammation and edema arises, developing groin pain (Heaton & Dorr, 2002). The pain can be alleviated with local infiltration of anesthetics (Wank, Miller, & Shapiro, 2004) or by surgically releasing (Heaton & Dorr, 2002) the iliopsoas tendon, but anti-inflammatory steroid injections are only short-term solutions.

Besides, the proven benefit of the large diameter femoral head to provide stability, there is also a disadvantaging element which causes soft tissue impingement, producing groin pain.

Patel et al. (2010) demonstrated that hip limitation of ROM occurs for hip flexion more than hip extension. Many researches states that increasing the diameter of the femoral head with a ROM significantly decreased the dislocation risk, but iliopsoas impingement may occur.

The purpose of this paper is to study the iliopsoas impingement with 3D modeling after total hip arthroplastie with large diameter prosthetic head or the acetabular component in retroversion with the hip in extension.

Materials and methods

Based on the CT images of a 27 year old male patient we created a 3D reconstruction of the pelvis, left femur and left iliopsoas muscle. We identified separately each of them, the identification was carried out automatically and manually. The transverse resolution was 0.929688 mm, thickness of the slices being 1.2 mm, in this way we obtained 257 sections.

The first step was segmenting each section (Figure 1.)

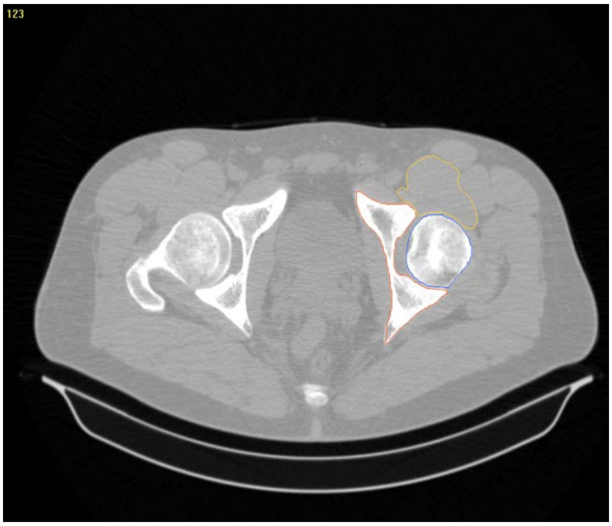

Figure. 1
CT image of the patient's anatomic components identified / red - hip bone / yellow - iliopsoas muscle / blue - femur

The formed layouts were clarified with non-uniform rational basis spline (NURBS) interpolation. We overlaid the achieved curves, after which, by using a NURBS plan, we have joined all together, thus creating a solid body (Figure 2.).

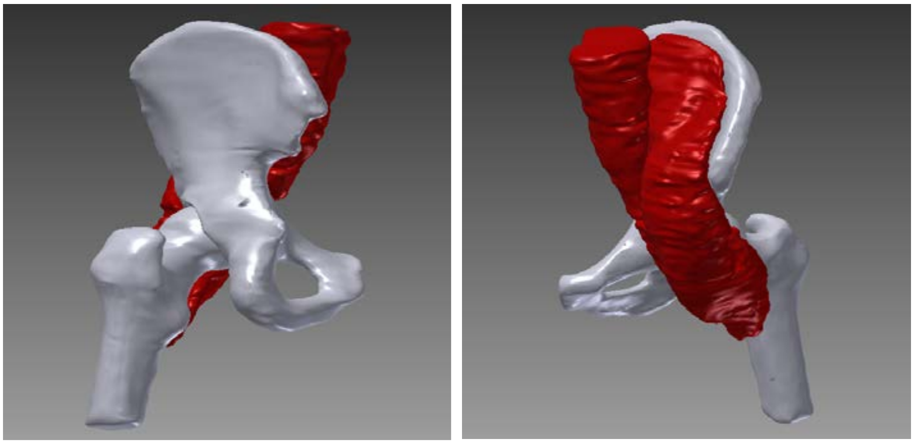

Figure 2.
Solid bodies - results of the NURBS plan

Using technical data from literature, we have defined the properties of the materials, choosing a muscle-like and bone-like consistency materials.

Prosthetic components were designed with 3D CAD program.

We proceeded with the osteotomy of the femur and then the final assembly took place (Figure 3.).

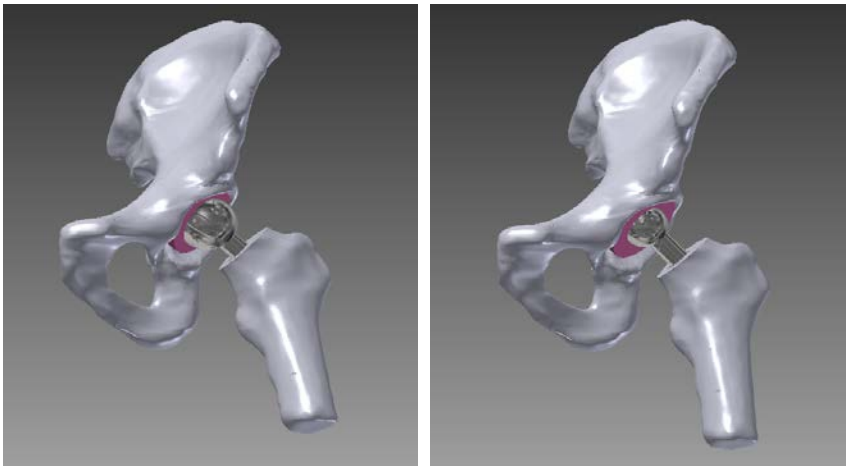

Figure 3.
Hip prosthesis with 36 mm and 28 mm mounted head

We performed the arthroplasty placing the acetabular component in a correct position using 28 mm and 36 mm diameter prosthetic heads. After this, we increased the acetabular component diameter and implanted it in a slightly retroverted position.

The finite elements analysis was performed in the following marginal conditions: with the pelvic bone in a fixed position; the iliopsoas muscle origin and insertion fixed link on both the femur and pelvis.

We considered the connection between the spherical surface of the femoral head and the acetabular component as mobile, sliding but inseparable.

On the distal end of the femur we hanged a weight corresponding of 400 Newton, and we pulled the iliopsoas muscle with a force of 500 Newton (Figure 4.).

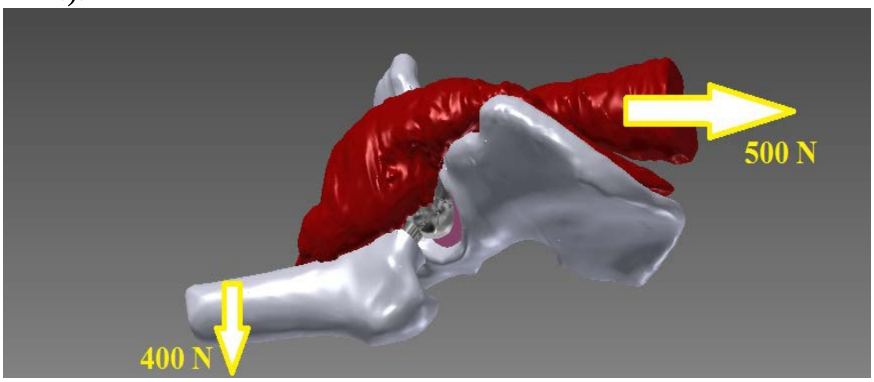

Figure 4.
The forces acting on and around the artificial joint

We measured the tension raised in the iliopsoas muscle in case of correctly positioned acetabular component with 28 mm and 36 mm prosthetic head and in case of the acetabular cup in retroverted position.

Results

Using the finite element method, there were no traces of impingement with the 28 mm diameter and 36 mm diameter femoral head, with the hip joint in extension (Figure 5.).

When the oversized acetabular component was inserted in a retroversion, we found stress raised at the iliopsoas muscle and acetabular component meeting point, which can cause local irritation and clinically may occur groin pain (Figure 6.).

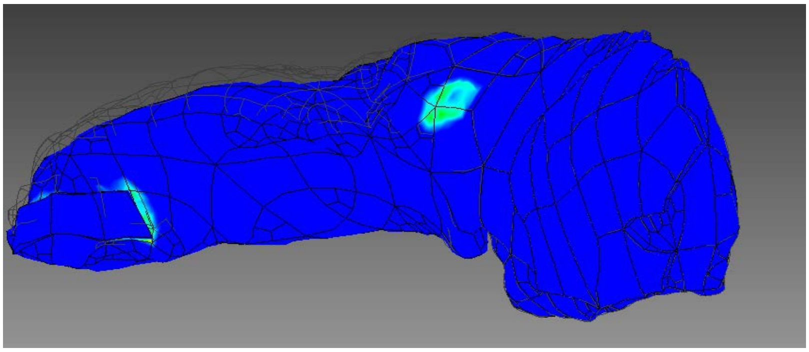

Figure 5.

No sign of impingement with the 28 mm diameter and 36 mm diameter femoral head, with the hip joint in extension

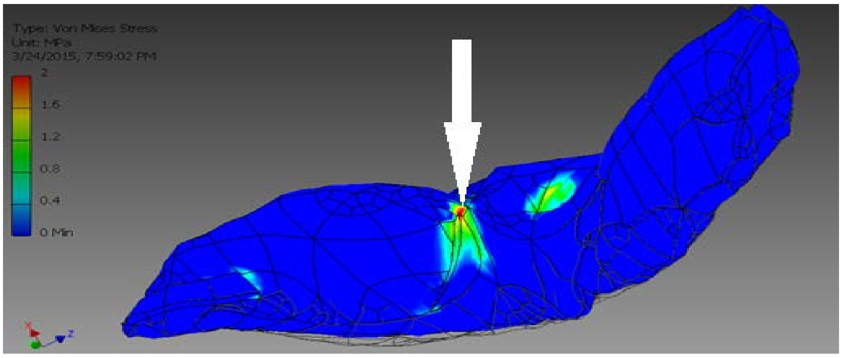

Figure 6.

Stress raised at the iliopsoas muscle and acetabular component meeting point

Discussion

Introducing and generalizing the surgical method of using a large femoral head (≥36 mm) in case of total hip prostheses, offered an increased ROM for the patient combined with a high degree of stability and security.

Browne, Polga, Sierra, Trousdale, & Cabanela, (2011) has documented groin pain caused by capsular and iliopsoas muscle impingement. They documented cases of severe groin pain and iliopsoas impingement with total endoprosthesis with a large diameter head. These symptoms were treated by releasing the iliopsoas tendon along with decreasing diameter of the femoral head. Releasing the iliopsoas tendon can compromise the hip joint function, the iliopsoas muscle being one of the strongest hip flexor muscle.

Bartelt, Yuan, Trousdale, & Sierra, (2010) observed that there is a high rate of significant groin pain in patients with large diameter head endoposthesis compared with the conventional ones.

Baumgarten K.M., (2012) documented the appearance of groin pain caused by impingement iliopsoas muscle even after conventional total hip arthroplasty.

Other publications and articles on the subject document cases where the evaluations were done in patients after total hip replacement using large diameter femoral head, but in flexion position.

Soft tissue impingement of the hip joint is not a disease. It is a pathological conditions based on biochemical and mechanical process that induces current groin pain.

K. M. Varadarajan at al. (2013) demonstrated the presence of ilipsoas impingement after total hip arthroplasty using a large diameter femoral head. They performed the 3D modeling and finite element analysis in the flexed position of hip.

The use of an anatomically contoured design femoral head may be a good solution. This type of prosthetic head does not affect the mechanical performance of the joint and is well supported by soft tissues.

Other studies have proven (as we did) with the 3D modeling method and analysis of finite elements, that the presence of iliopsoas muscle impingement is caused by the malposition of the acetabular component after total hip arthroplasty.

Conclusion

In our research, we demonstrated by 3D modeling and finite element analysis that after total hip arthroplasty using a large diameter femoral head, with the hip in extension, there is no pressure on the surface of iliopsoas muscle.

We have proven that the malposition of the acetabular component creates a pressure area that generates impingement in the iliopsoas muscle and possible groin pain.

Our proposal - sustained by the results presented in this paper and by other results published on this subject in the specialized literature – is that the iliopsoas impingement can be avoided by positioning the acetabular component in 45^o inclination and 10^o anteversion, also using a large diameter and anatomically contoured design femoral head with the same ROM and stability as the conventional ones can improve the clinical results.

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