A Comparative Case Study of the Pre and Post Operative Stress Distribution In a Dysplastic Hip Joint

Freddy L. Bueno-Palomeque [1], Carlos J. Cortés-Rodríguez [1,2], Carlos D. García-Sarmiento [1,3], Mauricio Cuervo-Campos [1]

[1] Biomechanics Research Group, Universidad Nacional de Colombia, Bogotá, Colombia; [2] Department of Mechanical Engineering and Mechatronics, Universidad Nacional de Colombia, Bogotá, Colombia; [3] Department of Surgery, Universidad Nacional de Colombia, Bogotá, Colombia.

UNIVERSIDAD NACIONAL DE COLOMBIA SEDE BOGOTÁ

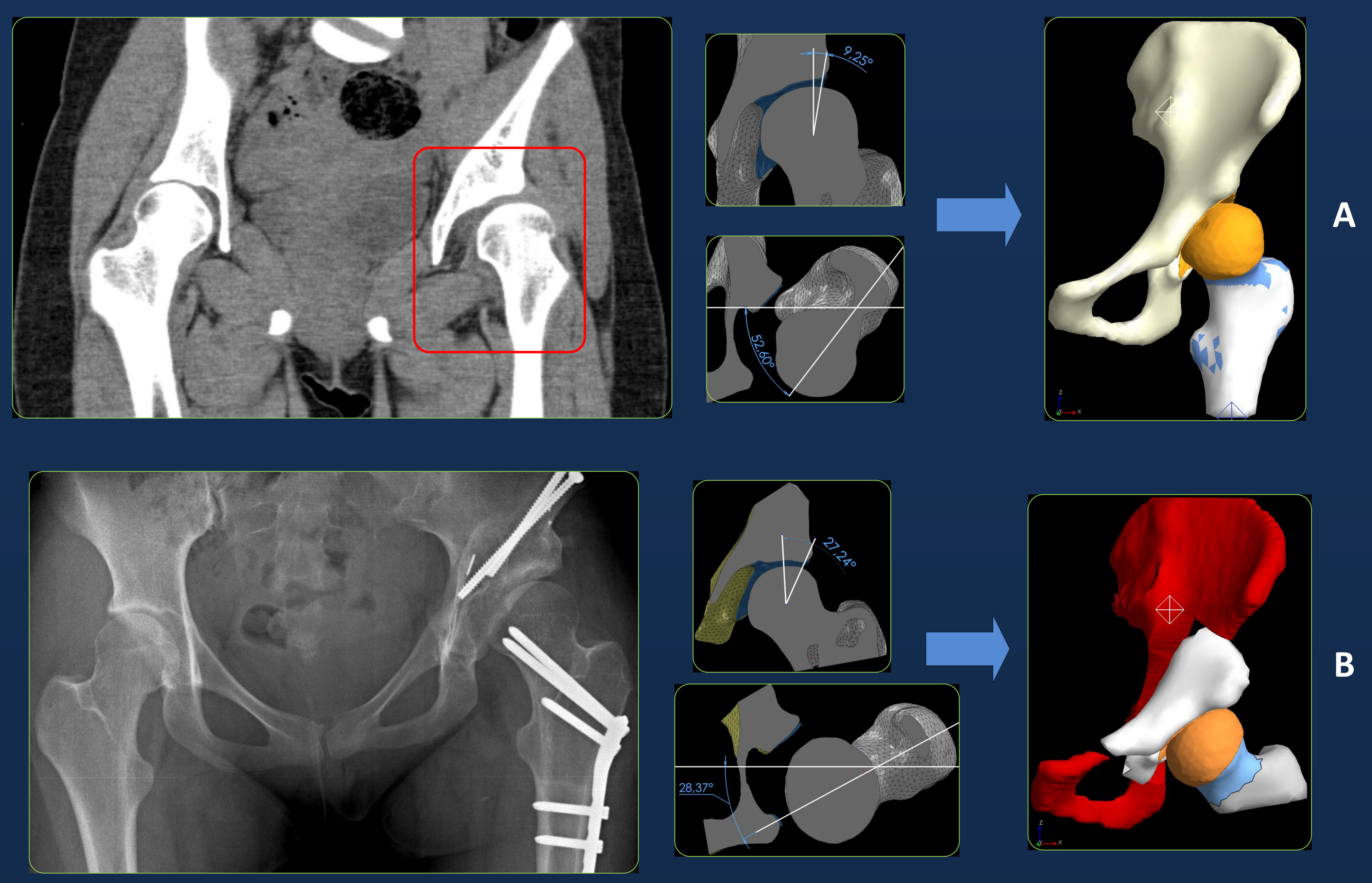
BIOMECHANICS RESEARCH GROUP GIBM cjcortesr@unal.edu.co

Introduction

Residual hip dysplasia in young and adult people requires a surgery in order to treat the pathology. Simulations of the surgery process proposed by the Surgeon allow us to estimate the future stress distribution generated in the hip joint, which help us to have a clear idea to focus and define the best surgical process to perform. This investigation aims to obtain and compare the stress distribution on a dysplastic residual hip joint on two scenarios: standing on two legs and single leg standing, before and after surgery, using finite elements analysis on a three-dimensional model constructed from CT scanning images of the patient.

Methods

- CT scanning images from a 16 year-old female patient with residual dysplasia.
- A three-dimensional model was developed in Invesalius v3.0. [1].
- Nearly constant cartilage thickness (1 ± 0.3 mm) developed from the bone geometry.
- All finite element models were meshed using tetrahedral elements Tet4.



MATERIAL PROPERTIES	E (MPa)	v
CORTICAL BONE	14000	0.29
TRABECULAR BONE	700	0.2
SUBCHONDRAL BONE	1150	0.24
CARTILAGE	13	0.38

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Figure 1: A) TAC image of dysplastic hip joint and the finite element model. B) Radiography post-operative and the finite element model of the articular relocation. C) Material properties assigned to the components of the model.

- Cortical, trabecular and subchondral bone were represented as elastic, isotropic material. Cartilage was represented as an incompressible Neo-Hookean hyperelastic material. Acetabulum was represented as a rigid body.
- A Post-operative model constructed from the femoral and acetabular osteotomy.
- The finite element analysis was developed using Febio v1.5. [2].
- Load: 200 N (0.5 Weight Body) simulating a bipedal stance and 873 N (2.22 WB) simulating on one leg standing [3].

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Results

- The results showed a high load on the pathological joint due to the low coverage of the femoral head (Table 1).

	TWO-LEGGED STANCE		ONE-LEGGED STANCE	
	PRE-OPERATIVE	POST-OPERATIVE	PRE-OPERATIVE	POST-OPERATIVE
MAX. STRESS (MPa)	3.00	1.70	7.21	5.25
CONTACT AREA (mm²)	103.74	167.30	207.29	302.14
CONTACT PRESSURE (MPa)	8.18	4.30	16.83	10.90

Table 1: Maximum stress generated on the femoral head. Contact pressure and the contact area in the articular cartilage.

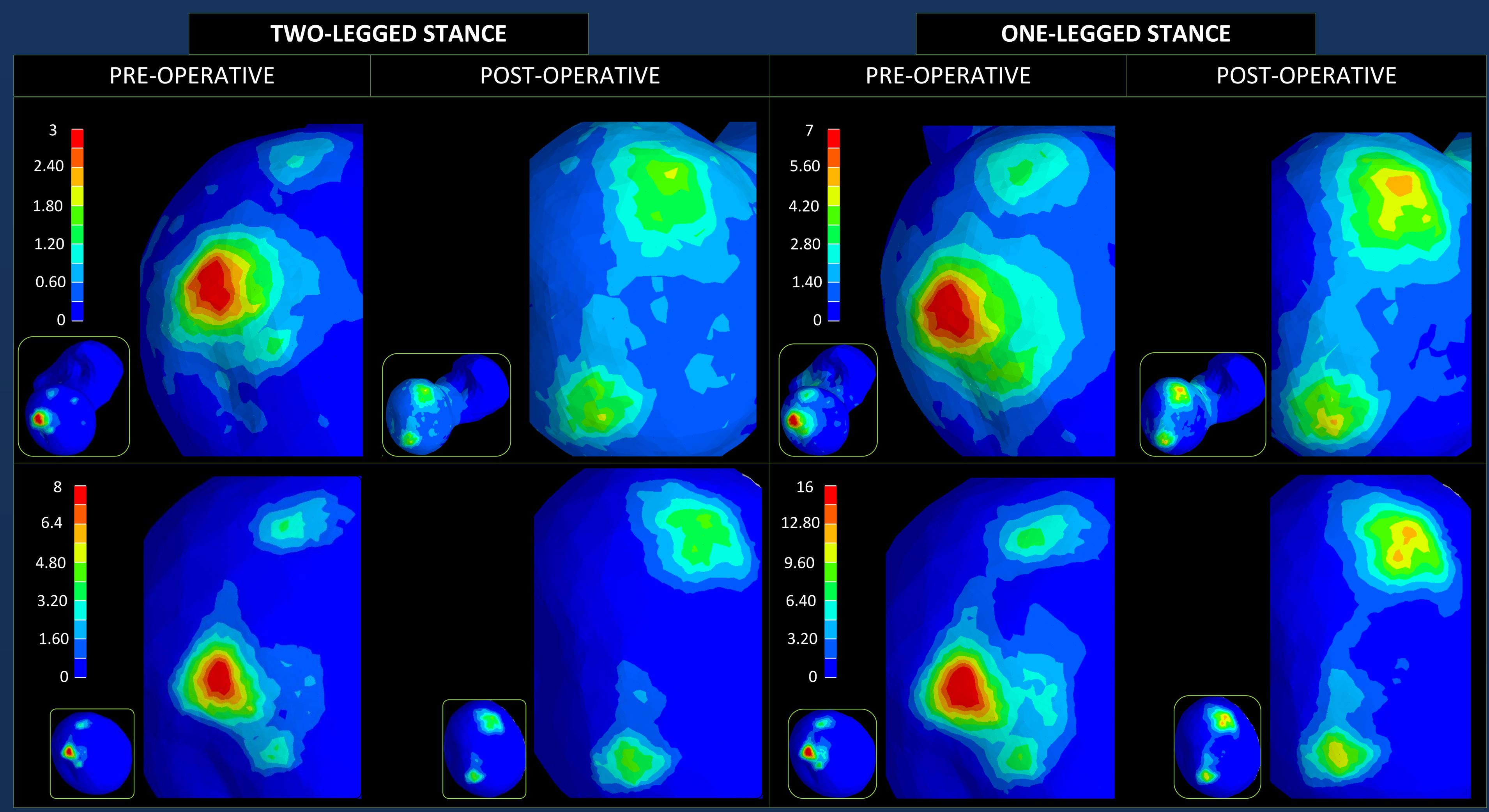

Figure 2: Stress distribution on the femoral head pre and post-operative, during the two and one-legged stance. Contact pressure on the articular cartilage pre and post-operative during the two postures.

- Two-legged stance: Maximum stress generated on the femoral head is **43.00%** lower on the post-operative model, contact area increment of **61.20%** and the contact pressure on the articular cartilage was reduced in **47.40 %** (Figure 2).
- One-legged stance: Maximum stress generated on the post-operative femoral head showed a reduction of **27.10%**, apart from an increment of **45.70%** in the contact area and a reduction of **35.20%** in the contact pressure on the articular cartilage (Figure 2).

Conclusions

- These results showed a substantial biomechanical improvements in the level of load that the hip joint post-operative would support.
- Some limitations of this study include the material properties assigned, the irregular cartilage contact [4], [5], the resultant force applied on the hip was calculated taking into account only six muscles [3] and was only considered the vertical component of the vector.
- This method could be useful to the surgeon to plan and evaluate different surgeries.

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