INFLUENCE OF ACETABULAR AND FEMORAL OFFSET ON HIP CONTACT FORCES FOLLOWING TOTAL HIP ARTHROPLASTY

Enrico De Pieri (1), Federica Atzori (1), Stephen J. Ferguson (1), Michael Leunig (2), Martin Aepli (2)

1. Institute for Biomechanics, ETH Zurich, Zurich, Switzerland; 2. Hip Service, Schulthess Klinik, Zurich, Switzerland;

Introduction

Surgical variables play an important role in determining the success of Total Hip Arthroplasty (THA). Previous studies have reported on the benefits of cup medialization during the procedure. The medialization of the acetabular cup to the true acetabular floor decreases the lever arm of the body weight about the hip joint and leads to a better fixation in the bone [1]. Additionally, cup medialization is usually performed with an equivalent increase in the femoral offset that maintains a physiological lever arm for the abductor muscles and supports a level pelvis during gait. Nevertheless, the medialization of the implant can be a potential cause for bone impingement, with the associated reduction in range of motion, while the loss of additional bone stock could compromise the possibility of a revision surgery [2].
The purpose of this study was to quantify the benefits associated with cup medialization, from a whole-body-scale biomechanical perspective.

Methods

Musculoskeletal simulations were run in the AnyBody Modelling System in order to analyze the influence of different surgical configurations on the hip contact forces and moments. The simulations were based on the MoCap Lower Body Model from the AMMR repositories. A generic marker and ground reaction force dataset was provided to simulate the gait of an average healthy subject. Three different surgical configurations were identified and implemented in the model: (1) anatomical reconstruction; (2) medialization of the acetabular cup with global offset restoration, based on recommendations by Bonnin et al. [1]; (3) medialization of the cup without global offset restoration. An inverse dynamics analysis was then performed to compute hip contact forces and moments as well as activity of the abductor muscles.

Results

The medialization of the prosthesis (2) lead to an overall decrease in the hip contact forces, particularly during the loaded stance phase, in which the contact forces were reduced up to 7.8% compared to the anatomical restoration (1). Consistent trends were also observed for the abduction and external rotation moments (reduced up to 27% and 10%, respectively). The maximum muscle activity of the abductor muscles was also reduced due to the lower moments associated with the medialization of the cup (3); their activity was further reduced with restoration of the femoral offset (2), which lead to a reduction of the maximum muscle activity up to 20% compared to the activity profiles obtained for the anatomical reconstruction.

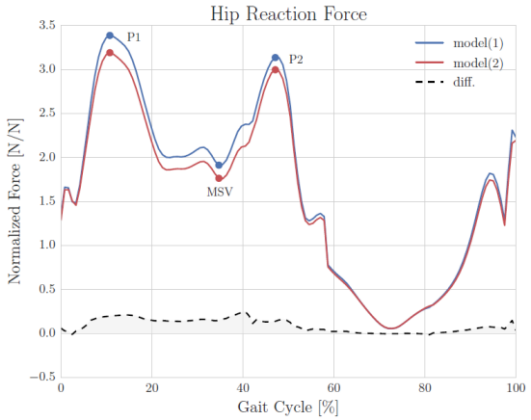

Figure 1: Total Hip Reaction Force during gait in two configurations: anatomical reconstruction (1) and cup medialization with global offset restoration (2).

	Hip Reaction Force [BW]		
	model (1)	model (2)	% variation
First peak force	3.39	3.19	-5.79
Second peak force	3.14	3.00	-4.42
Midstance valley	1.91	1.76	-7.80

Table 1: Comparison of peak and mid-stance force values for the configuration (1) and (2).

Conclusion

This study confirms that medialization of the prosthetic head with a compensatory increase in the femoral offset provides an advantageous reconstruction strategy in total hip arthroplasty, concerning joint loading. This is consistent with the general teachings of Pauwels [3].The medialization of the acetabular component can lead to an important reduction of the peak contact forces during the stance phase, while the combined effect of cup medialization and femoral offset restoration reduces the maximum loads on the muscles of the abductor compartment.

References

1. Bonnin et al, Hip Int, 22.4:371-378, 2012.
2. Terrier et al, Clin Orthop Relat Res, 472:3159-3165, 2014.
3. Pauwels, Biomechanics of the Normal and Diseased Hip, 1976.

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