Standing Anterior Pelvic Tilt is Correlated with the Proximal Femur Shape of Individuals with Cam Morphology

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Summary

Femoroacetabular impingement syndrome (FAIS) and hip osteoarthritis (OA) are linked to aspherical femoral head (cam) morphology. However, 2D radiographic evaluation of cam deformities and inaccuracies in skin marker motion capture make the role of the cam in development of symptoms unclear. Statistical shape modeling (SSM) and biplane videoradiography (BVR) were used to demonstrate that reduced standing anterior pelvic tilt was correlated with femur shape of individuals with cam morphology, independent of symptoms. Findings herein provide insight into the pathophysiology of FAIS and could inform conservative treatment focused on pelvic posture modification.

Introduction

Cam morphology is associated with FAIS and hip OA. However, ~35% of the population has cam morphology without a history of hip pain or evidence of hip OA [1], clouding its role in FAIS symptomatology. Limitations in 2D radiographic evaluation of cam deformities and inaccuracies in skin-marker motion capture have contributed to uncertainty in form-function relationships. SSM, which characterizes 3D shape, combined with model-based tracking of BVR offers an objective and accurate approach for evaluating 3D femoral morphology and *in vivo* kinematics. Herein, SSM and BVR were used to establish the role of cam morphology on *in vivo* hip and pelvis orientation while standing.

Methods

Symptomatic patients with cam FAIS and asymptomatic individuals with (positive control) and without (negative control) cam morphology were recruited under IRB approval (Table 1). Two orthopedic surgeons identified cam morphology from plain film x-rays. The hip of interest was imaged with BVR while standing, and CT or MRI data were used to reconstruct the femur and pelvis for hip and pelvis orientation calculations [2]. Femur reconstructions were added to a previously published proximal femur SSM (n=124) [3]. This SSM served as a canonical model to objectively characterize femur shape. Specifically, linear discriminant analysis provided 'shape scores' (SScores), where the asymptomatic and symptomatic canonical mean proximal femurs were classified and normalized between -1 and +1, respectively. Comparisons of mean SScores and standing posture were evaluated between study groups. Correlations between hip and pelvis orientation and SScores were assessed, and groups were compared using *t* tests with Holm-Sidak correction for multiplicity (α=0.05).

Table 1: BVR population demographics. BMI in kg/m^2

	Side	Sex	Age	BMI
Patient (n=15)	9R / 6L	8M / 7F	29 ± 6.6	24 ± 3.4
Pos ctrl (n=7)	6R / 1L	3M / 4F	24 ± 2.9	23 ± 2.7
Neg ctrl (n=10)	6R / 4L	5M / 5F	23 ± 2.3	21 ± 2.0

Results and Discussion

Patient and positive control femur shape was not significantly different. Proximal femur SScores for negative controls (-1.6±1.5) was distinct from patients (1.4±2.7, p=0.004) and positive controls (1.2±1.6, p=0.003). Further, patients stood with more hip extension (-1.4±5.3°, p=0.009) and less anterior pelvic tilt (4.2±6.2°, p=0.048) than negative controls (5.2±4.2°, 10.1±4.3°). Positive controls had no significant postural differences from either group. SScore was negatively correlated with hip flexion (r=-0.37; p=0.037) and anterior pelvic tilt (r=-0.38; p=0.031) (Figure 1).

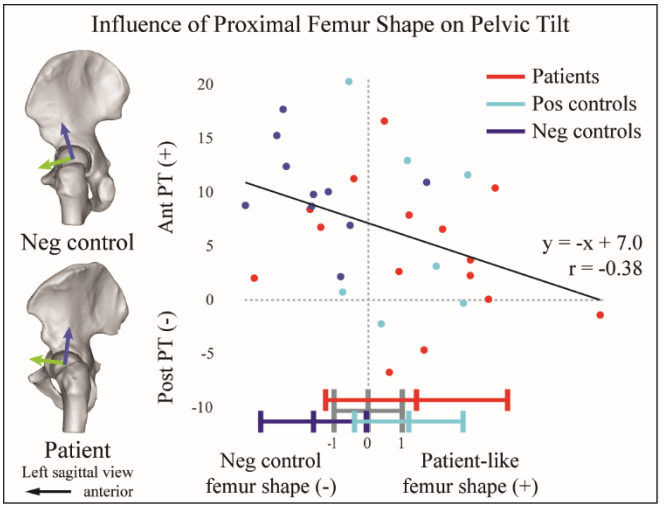

Figure 1: Population SScores correlated with standing pelvic tilt (PT) values (middle) with distribution (mean ± SD) of group SScores (bottom). Negative control participant and patient hip in the standing posture showing greatest ± PT of these two groups (left).

Conclusions

This study provides unique insight into the pathophysiology of FAIS by relating an objective measure of femur morphology to pelvic tilt. Future work will evaluate this femur shape-pelvis kinematic relationship during dynamic activities to establish more robust symptom-avoiding compensatory strategies. These findings could lead to new conservative treatments of FAIS that emphasize pelvic posture modification to alleviate impingement symptoms and hip OA development.

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References

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