Motion Analysis of Patients with FAI and the influence of Pelvic Tilt

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INTRODUCTION:
Femoroacetabular impingement (FAI) causes abnormal femoral contact at the anterosuperior aspect of the acetabulum in activities requiring a large hip range of motion (ROM). Cam impingement is caused by decreased concavity of the femoral head-neck junction which results in forceful inclusion of the proximal femur into the peripheral acetabulum at the limits of hip ROM. FAI is a relatively new diagnosis which is a recognized cause of idiopathic osteoarthritis (OA). Due to this connection with hip OA, it is imperative to diagnose and correct FAI before the onset of OA. However, FAI is often misdiagnosed and remains an evasive condition to diagnose. For this reason it is important to measure how it effects movement in order to increase our understanding of this pathology, and to develop diagnostic criteria.

The purpose of our study was to evaluate motion analysis in patients suffering from FAI compared to normals to gain a better understanding of the pathomechanics of this condition.

METHODS:
We measured the effect of cam FAI on the three-dimensional kinematics of the hip and pelvis during a maximal depth squat as compared with a healthy control group. Fifteen participants diagnosed with cam FAI and 11 matched control participants performed unloaded squats while three-dimensional (3-D) motion analysis was collected. The cam impingement participants were recruited after having a positive impingement test and visible cam morphology on anteroposterior (AP) and Dunn view radiographs. The alpha angle was measured on each hip with a value greater than 50.5° diagnostic of cam-type FAI. Control participants had no history of serious lower limb injury or surgery, and had spherical femoral heads which were assessed by an AP radiograph. Participants from both groups were excluded if hip OA was visible on the radiographs or if they had substantial hip joint space narrowing. Before participating in the study, which was approved by the Ottawa Hospital Research Ethics Board and the University of Ottawa Health Sciences and Science Research Ethics Board, all participants signed an informed written consent.

Three-dimensional kinematics of squatting was collected using seven VICON MX-13 cameras (VICON, Los Angeles, Calif.) at 200 Hz with retroreflective markers placed on anatomical landmarks. A height-adjustable bench was used to control squat depth indicating maximal ROM (pitch) of 14.7 ± 8.4° compared to 24.2 ± 6.8° in the control group.

Participants stood in front of the bench which was adjusted to ⅓ of their tibial height. Starting from neutral stance, participants squatted down to their maximal attainable depth and return to a standing position in a slow controlled movement, maintaining heel contact throughout the movement. This was repeated five times, and the 3-D hip and pelvic kinematics were calculated and averaged for each participant, and ensemble averaged for the control and FAI groups. While deep squatting is not itself a common daily activity, it is a component of frequent activities, such as tying shoes and proper lifting technique and requires a large hip and pelvic ROM.

Squat kinematic variables consisted of the peak hip angle in each plane at maximal squat depth, the peak 3-D pelvic angles during descent, ascent and at peak depth, the total pelvic ROM in each plane and the maximal attained squat depth. Differences in these variables between the two groups were determined using One-way between-subjects ANOVAs (α = 0.05). Any significant differences in the aforementioned dependant variables between the two groups (p < 0.05) also had an ANCOVA run with squat depth included as a covariate. This was to ensure that the differences in joint kinematics resulted from the presence or absence of cam FAI, rather than from discrepancies in squat depth. All statistical calculations were processed using SPSS 15.0 software (SPSS Inc., Chicago, USA).

RESULTS:
The FAI group had a decreased (p = 0.005) mean sagittal pelvic ROM (pitch) of 14.7 ± 8.4° compared to 24.2 ± 6.8° in the control group (Fig 1). When squat depth was included as a covariate, mean pelvic pitch remained significantly reduced (p < 0.01) in the FAI group compared to the control group. However, there were no differences in any of the 3-D hip angles at maximal squat depth.

The control group also squatted to a lower (p = 0.037) mean maximal squat depth of 32.3 ± 6.8° of leg length, compared to the 41.5 ± 12.5° attained by the FAI group. Only 5 participants from the FAI group (33%) reached the lowest attainable squat depth compared to 10 controls (91%) as indicated by buttocks contact with the height adjustable bench.

DISCUSSION:
There are some limitations inherent to joint kinematic studies which are a result of generic calculations, marker misplacements and skin or clothing artefacts. However, precautions were used to minimize the potential errors caused by these limitations.

There were no differences in hip kinematics, but perhaps the most important finding was the difference in the total sagittal range of pelvic tilt during maximal-depth squat between the control and FAI groups. Not only was the range of pelvic tilt lower in the FAI group, it was also independent of squat depth. The control group had much more pelvic tilt than the FAI group, with an increased incline during descent and ascent, and increased recline at peak squat depth. The largest difference occurred in recline at peak depth (Fig 1).

The more the pelvis is reclined, the less acetabular retroversion occurs which is associated with anterior FAI. In fact, it has been suggested that pelvic retroversion may be caused by inclined pelvic pitch. This indicates that pelvic recline orients the acetabulum in such a way to minimize contact between the acetabular rim and the anterosuperior femoral head-neck junction, by decreasing anterior femoral head coverage. Reduced sagittal pitch may predispose the hip joint to premature contact between the proximal femur and the acetabular rim, especially in movements requiring high levels of hip flexion. The idea that pelvic mobility may be partially responsible for the abnormal contact between the anterosuperior acetabulum and the proximal femur is novel and may represent a key feature in the pathomechanics of FAI.

There was also a difference in maximal squat depth, with the control group squatting deeper than the FAI group. Only 33% of FAI participants could attain maximal squat depth compared to 91% of the controls. This indicates that maximal depth squats may be a useful investigative tool in the evaluation of FAI.

REFERENCES: