MAXIMAL DEPTH SQUATING IN ASYMPTOMATIC UNILATERAL CAM FAI

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Femoracetabular impingement (FAI) is a condition that causes hip joint pain and has been found to result in decreased range of motion. However it is not known whether biomechanical deficiencies are associated with the mechanical impingement or further underlying issues associated with pain. This study consisted of comparing the squat biomechanics of two FAI groups to a matched control group. It was found that the asymptomatic group had squat performance very similar to the control group. Both the control and asymptomatic groups were able to squat to a deeper depth, had greater pelvic range of motion and a larger maximum hip flexion angle. These findings suggest that the bone deformity might not be directly related to restricting motion for the squat, and an issue of soft tissue damage and muscle problems may be the root cause, and should be the next avenue of study.

KEY WORDS: femoroacetabular impingement, FAI, squat, hip.

INTRODUCTION: Femoroacetabular impingement is an aspherical anatomical deformity located at the hip joint that can result in symptoms of pain and physical impingement that hinders range of motion, and typically prevents the person from participating in sports. Cam FAI occurs mostly in young athletic males, at a prevalence of 17% of the population (Ganz, Parviz, Beck, Leunig, Notzli & Siebenrock, 2003). Corrective surgery for FAI is one of the leading arthroscopic hip surgery among professional and Olympic athletes, accounting for 36% of all hip surgeries (Philippon & Schenker, 2005). Furthermore, amongst hockey players, 81% of corrective hip arthroscopic surgeries are FAI related. While most surgical interventions are considered successful with athletes returning to sport, continued insight into the pathomechanics of FAI will be useful to the sport community. To date, studies have been done on the effects FAI has on the biomechanics daily functional tasks. We previously discovered that FAI subjects had a restricted pelvic motion when compared to age, BMI and age matched controls (Lamontagne & Kennedy 2009). We also have found that FAI patients who went into surgery to repair and clear the impingement had an improved maximum squat depth after surgery (Lamontagne, Brisson, Kennedy & Beaule, 2011). What remains unknown is whether the deficiencies in squat performance are due to the mechanical impingement of having an abnormal femoral head-neck junction, or a result of pain and muscle control disorders. This study compared the kinematics of squat of symptomatic FAI (sFAI) subjects who have the aspherical femoral head, labral damage and pain symptoms, asymptomatic FAI who have bone deformity at the femoral head/neck junction but no symptoms of pain and an age-, gender- and BMI-matched control group.

METHODS: In total, 18 participants were recruited, with 6 in each group: sFAI (FAI patients 1 month before surgery, 6 males, 37.5 ± 5.6 years, 26.4 ± 3 BMI), aFAI (asymptomatic FAI patients, 5 males, 1 female, 34.7 ± 7.5 years, 26.4 ± 3 BMI), and controls (5 males, 1 female, 34.5 ± 4.9 years, 26.0 ± 3.3 BMI). All subjects underwent a computerized tomography (CT) scan to confirm their status as an aFAI or control group. The symptomatic group also had a CT scan and MRI to determine the level of bone and tissue damage. FAI was diagnosed by the degree of asphericity of the femoral head. Patients were excluded if they had a history of other lower body injuries or a bilateral deformity. Following the CT scan, subjects proceeded to the Biomechanics Laboratory for motion analysis. A 10 camera Vicon MX system with 2 Bertec forceplates, and a 45 retroreflective full body marker set were used.

Electromyography (EMG) signals were collected bilaterally for erector spinae, tensor fasciae latae, gluteaus maximum, gluteaus medius, rectus femoris, biceps femoris, and semitendinosis. The participants were instructed to do a maximal depth squat, where they were told to keep their feet flat on the ground and shoulder width apart, squatting as low as possible without lifting their heels. A total of 5 good squat trials were collected and averaged for each subject. Lower body kinematics such as squat depth as a percentage of leg length, peak hip flexion, and pelvic range of motion (ROM), were calculated for the affected side as well as the controls dominance-matched side. The kinematic data were filtered with a Woltring filter set at 15 mean square errors. A one-way ANOVA analysis was performed on each of the above-mentioned variables with an alpha value of 0.05.

RESULTS: The aFAI and control groups were found to squat at a similar depth of 57.6% and 58.5% of leg length respectively while the sFAI group only reached 49.2% which was not significant (p = 0.16). The aFAI and control groups both had a larger pelvic ROM than the sFAI group. The aFAI and control groups performed their squat with 17.5° and 18.1° ROM respectively, while the sFAI group performed their squat with only 14.0° ROM (Figure 1). The pelvic ROM for the three groups were not significant (p = 0.37). Both the aFAI and control groups also had a higher peak sagittal hip flexion angle than the sFAI group. With maximum flexion of angle of 116.0° and 110.0° for the control and aFAI groups respectively, the surgical group only attained 96.6° of hip flexion (Figure 2). No significant differences were found amongst the three groups (p = 0.19).

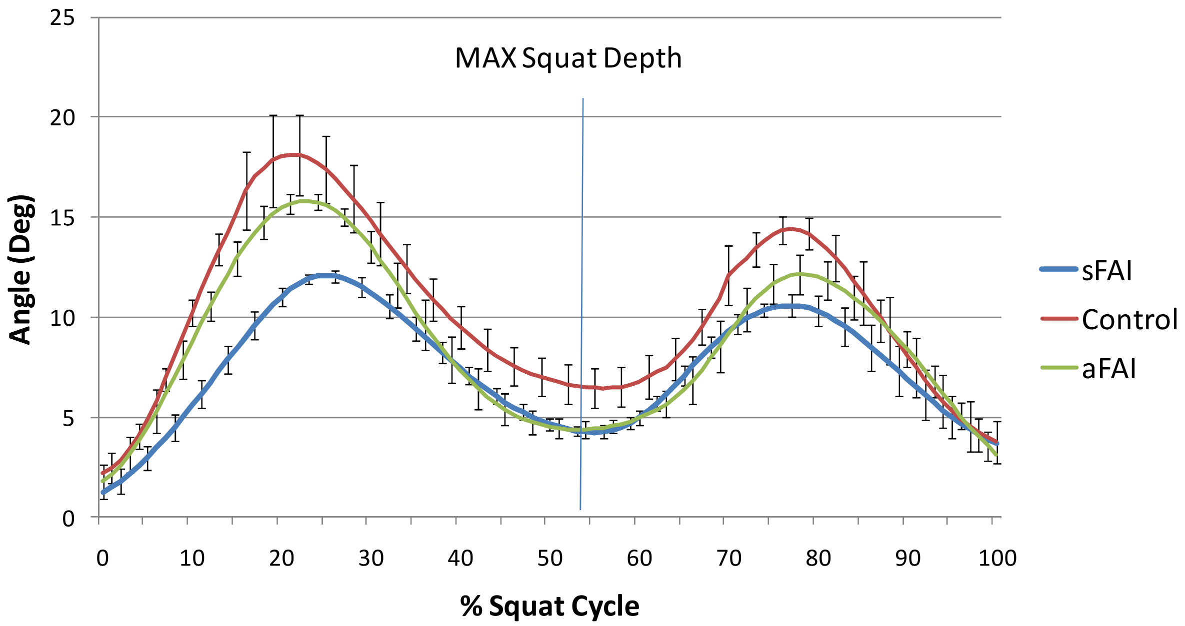

Figure 2 – Pelvic tilt ROM curves are reported for each group. The maximum squat depth occurs at 53% of the squat cycle.

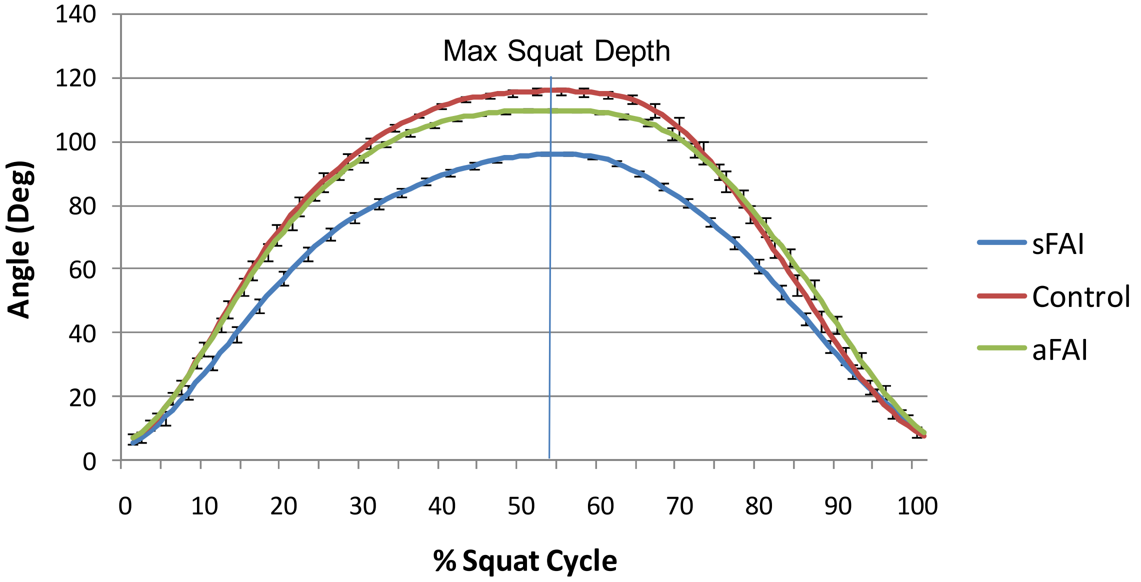

Figure 3 – The sagittal hip flexion angle curves are reported for each group. The maximum squat depth occurs at 53% of the squat cycle.

DISCUSSION: The aFAI and control groups had similar pelvis and hip kinematics compared to the sFAI group. The lower squat depth achieved by the aFAI group compared to sFAI group, although not significant, indicated that pain and joint damage could be a factor associated with the reduced squat depth, not mechanical impingement. We have found previously similar results in which sFAI had less squat depth that the control group (Lamontagne & Kennedy, 2009). Another study on squat task (Lamontagne et al., 2011) using post-corrective surgery of FAI patients showed an improvement of 3.7% in maximal squat depth. The corrective surgery consisted of bone resection of the deformity at the junction of the femoral head and neck. The post-corrective surgery patients after one year had reduced significantly the level of pain experienced. Since in this study the aFAI and sFAI groups only differed in terms of pain, and the aFAI and post-surgery FAI only differed in terms of bone deformity, this could indicate that the reduced maximal squat depth may be not related to mechanical impingement.

Additionally, the similar hip flexion angle and pelvic angle ROM between the aFAI and control group add further evidence that there is no major physical restriction by the bone deformity to prevent a maximal depth squat. Our previous study on symptomatic FAI subjects and a control group (Lamontagne et al., 2009) found a significant difference in pelvic ROM between groups, with the symptomatic FAI group experiencing lower ROM. In the current study, when we added an asymptomatic FAI group, it was found the aFAI group followed a very similar to control group pattern for pelvic ROM. Overall, the aFAI and control groups experienced larger pelvic incline at descent and ascent phases of the squat, and an equal pelvic recline at the peak squat depth that the sFAI group. Based on the previous results, and the observations from our study, this indicated that sFAI group, due to pain and/or impingement, is unable to incline their pelvis the same as controls and aFAI during the squat decent and ascent. Although not statistically significant, this trend could indicate that sFAI have lower ROM during squats. However, since only sFAI has pelvic ROM restrictions during the squat, and not the aFAI group, the limiting factor is not likely due to the actual mechanical impingement, but more the soft tissue damage and joint stiffness that is present in the sFAI group.

The lack of statistical significance in our results can be attributed to the small sample size. However, the trends found in the control and sFAI groups are corroborated with what has been found in our previous studies on FAI.

Aside from possible soft tissue damage, such as labral and cartilage damage, joint stiffness due to muscle co-activation could be a major limiting factor for sFAI. The EMG findings reported by Mantovani et al. (2012) indicated that muscle co-activation present in the sFAI

group during squats may limit the ability to reach maximal depth by affecting the pelvic and hip kinematics. As the squat progresses downward and pain begins to onset, the muscle co-activation then initiates, which stiffens the joint, limiting the depth of the squat.
By understanding the specific role of the bony impingement, tissue damage such as cartilage and labral lesions and potential muscle imbalance it would help to early diagnose the disease to prevent corrective surgery.

CONCLUSION: The squat biomechanics of asymptomatic FAI patients do not largely differ from the control group. The symptomatic FAI group reports smaller pelvic ROM, peak hip flexion angle, and squat depth, which have been previously reported. This indicates that the mechanical impingement may not be restricting during squats, but rather it is an issue of underlying tissue damage, pain, and joint stiffness. Further investigation into the biomechanical effects of the FAI deformity in other tasks, as well as the potential influences of muscle co-activation is suggested.

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