Biomechanical Effects of a Joint Effusion or Capsular Tear of the Hip Joint

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Introduction: Multiple factors contribute to the stability of the hip joint including bony anatomy, the hip capsule, corresponding ligaments, the articular labrum, the ligamentum teres, and a negative intraarticular pressure. Traumatic or iatrogenic disruption of these critical structures can lead to instability, pain, and disability. We hypothesized that violation of the negative intraarticular pressure of the hip joint by venting the capsule or simulation of a traumatic effusion would cause increased laxity in a cadaveric model. The resulting increased laxity could lead to further damage to critical structures around the hip including the labrum, ligamentum teres and the chondral surfaces.

Methods: IRB approval was obtained for the study. Ten hip specimens (5 Left, 5 Right hemi-pelvis to 215mm inferior to the joint line, age range 28 to 82 years) were obtained from local and statewide sources. All skin, subcutaneous tissue, and muscle was removed, while carefully retaining all aspects of the hip capsule. Each specimen had the femur and pelvis (iliac wing from the anterior superior iliac spine to the anterior inferior iliac spine) potted using urethane epoxy in a coupling that allowed it to be mounted into a custom joint testing machine. Each specimen was then mounted with the ASIS coupling locked in place and the femur fixed in 5 degrees of valgus to simulate neutral position. Specimens were tested with the femur at full extension and at 90 degrees of flexion in relation to the pelvis. A vertical force (30N) was placed on the femur to maintain joint contact during all tests. At each flexion angle, a 1.5Nm internal and external rotational torque was applied along the femoral axis while the pelvis was fixed. This torque was applied 3 times at each flexion angle to condition the specimen tissue. The third iteration was used as the normal reference test. The specimen then had a 10cc saline injection into the joint capsule to simulate a traumatic effusion and all tests were repeated. This was followed by an incision along the superior capsule using a #10 scalpel to vent the capsule and release the saline (this was placed in the 12 o’clock position to simulate where a trocar may be placed during a hip arthroscopy); each alteration was subjected to the same loads and positions as the intact hip specimen. The deflection in degrees at ±1.5Nm as referenced from the normal neutral position was then compared in the transverse plane to determine the laxity change of the joint capsule. A Wilcoxon signed rank test with a Bonferroni correction was used to determine statistical significance. With a Bonferroni correction, a p-value less than 0.025 was considered significant at the 95% confidence level. All statistical analyses were performed using SPSS version 21.0 (IBM-SPSS, Armonk, New York) software.

Results: Range of motion in extension was 24.1 to 70.7 degrees among the 10 hips, while range of motion in flexion was 33.9 to 100.3 degrees. On average, the saline effusion increased capsular rotational laxity compared to native hips in external rotation in both extension and flexion; the vented capsule increased laxity in both external rotation in flexion and internal rotation in extension. Little change (<0.5 degrees) was seen in the remaining conditions. Saline effusion statistically altered external rotation in extension (p=0.021), and venting the capsule statistically altered internal rotation in extension (p=0.015).

Discussion: We hypothesized that simulating a traumatic effusion of the hip joint with saline would disrupt its vacuum effect and lead to increased hip laxity. However, our injected specimens increased external rotational stiffness in both flexion and extension with greater effect on the specimens in extension. Wingstrand et al demonstrated that the presence of an effusion leads to increased pressures within the joint in flexion and extension, thus decreasing the pressure leads to less range of motion across the hip. The presence of a joint effusion may affect the stability afforded to the hip from negative capsular pressure if it is not associated with initial capsular or labral disruption at the time of injury. Instead, by increasing pressure within the joint, it may increase tension within the capsular ligaments which may, in turn, lead to the increased hip stiffness seen in our study. Previous studies have shown increased hip laxity when the negative intraarticular pressure of the hip joint is violated. Some studies have demonstrated that less force is required to distract the joint when the capsule is vented.1,4 Others have demonstrated increased external rotation and subluxation when a 20 gauge needle is used to eliminate the negative pressure of the hip joint when the iliofemoral capsular ligament is incised.3 Our findings similarly showed venting the capsule increased external rotation in 90 degrees of hip flexion. The iliofemoral ligament is a known restraint to external rotation.2 An incision along the superior capsule would likely violate this structure and contribute to the increased external rotation seen in our study along with the capsular venting effect. Interestingly, our incised specimens demonstrated increased internal rotation in extension, contrary to previous findings by Myers et al. who found no significant effect on internal rotation in their sectioned specimens.3 Potential limitations to the study include whether the statistically significant results seen in the study are of clinical significance. While it is possible that the small differences in rotation seen in our study may cause microinstability and alteration of hip biomechanics, the degree of change in rotation in the observed conditions may not be enough to cause labral or chondral injury or joint destruction. In our study, we vented the capsule with a capsulotomy incision. Therefore, it is not possible to determine if the
resultant increased external rotation seen in flexion is the result of releasing the negative intraarticular pressure or a result of releasing the soft tissue restraint to external rotation of the capsule.

**Significance:** Venting of the capsule, as seen in traumatic capsular or labral disruption and during arthroscopic capsulotomy may increase laxity of the hip which can lead to further injury to structures about the hip and cause instability. The presence of an effusion alone may not violate the negative intraarticular pressure within the joint and may not lead to hip instability but traumatic tears or recovery from hip arthroscopy may destabilize the joint and should be considered during the post-operative period and during physical therapy.

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**References:**