Femoral Head-Neck Junction Over-resection Causes Intra-Articular Labral Deflection: An Ultrasound-Based Study

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INTRODUCTION: Hip arthroscopy for femoroacetabular impingement (FAI) has grown rapidly in the United States, increasing 600% from 2006–2010 and 85% from 2011–2018. Osteochondroplasty with labral repair is now the gold standard in treating FAI, offering low complication rates, high patient satisfaction, and significant pain and functional improvement. Despite favorable outcomes, revision rates remain at about 7%. Historically, revisions were most often due to inadequate cam resection, causing recurrent impingement and labral re-tear. More recently, however, other failure mechanisms have been recognized, including femoral neck overresection. Overresection removes excessive bone from the head-neck junction, creating a "shark bite" deformity rather than a smooth transition from head convexity to neck concavity. This iatrogenic pathology may cause inferior outcomes, as the defect disrupts femoral contact with the anterosuperior labrum and breaks the suction seal, potentially leading to pain and instability. However, the biomechanical consequences of overresection are not well understood. It has been demonstrated that the femoral neck defect engages the labrum and causes disruption of the hip suction seal, leading to greater hip distractability. However, suction seal disruption may not fully explain all the effects of overresection on hip joint mechanics. The purpose of this study was to evaluate labral motion in the native state and after femoral neck overresection in a cadaveric model. It was hypothesized that a femoral neck defect would cause increased labral and capsular deflection into the joint during hip flexion.

METHODS: Five cadaveric hip specimens were evaluated (age: 49.5 ± 8.7, 3M:2F). Native labrum and capsule motion from maximal extension through maximal flexion was evaluated using video ultrasound imaging. A surgical capsulotomy and standardized overresection defect were created in the anterior superior femoral neck. Labrum and capsule motion were reevaluated on video ultrasound. Ultrasound images of labrum and capsule position in maximum hip extension and maximum hip flexion were extracted and overlaid using image analysis software (Figure 1). Differences in absolute maximum labral tip deflection, radial labral tip deflection, and radial capsule deflection were compared between native and overresection states using a paired T-test.

RESULTS: Graphical display of the results can be found in Figure 2. All five cadaveric hip specimens demonstrated increased labrum and capsule motion with femoral neck overresection. Mean radial labrum deflection increased from 0.47 mm (outward) in the native state, to -2.08 mm (inward) in the overresection state ($p=0.003$). Mean maximum labral tip displacement increased from 0.96 mm in the native state to 3.41mm in the overresection state ($p=0.009$). Radial capsule deflection increased from 0.30 mm (outward) to -4.69mm (inward) with overresection ($p=0.005$).

DISCUSSION: The most important finding of this study is that cam overresection leads to an increase of inward labral deflection of about 2.5 mm and an increase of inward capsule deflection of about 5 mm with a standardized 5 mm by 200 mm defect. This confirms the initial hypothesis. The present study documents a newly observed phenomenon in which cam overresection leads to pathologic inward displacement of the labrum and capsule. This phenomenon may help explain the pain and dysfunction that occurs with cam overresection. Furthermore, these observations may provide a theoretical basis to the benefits of the remplissage procedure. In this procedure, the defect of the head neck junction is filled using a soft tissue graft, typically IT band allograft. This filling of the defect, in addition to maintaining the suction seal, may indeed prevent pathologic labral motion, prevent capsulolabral incarceration within the defect, and may restore normal capsulolabral function. This may be a useful area of future investigation. This study is limited in that 1) it employs a cadaveric model that may not replicate in vivo capsulolabral dynamics, 2) capsulolabral motion was not measured after cyclic motions, which is typically when overresected patients feel pain and discomfort, and 3) the effect of a treatment state was not investigated for its effect on capsulolabral motion.

CLINICAL RELEVANCE: This study demonstrates that femoral neck overresection causes increased motion of the labrum and capsule into the hip joint, providing a theoretical basis for pain and recurrent labral tearing associated with cam overresection.

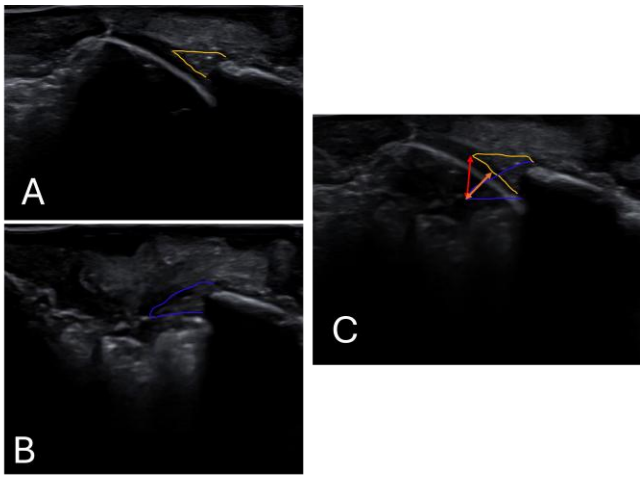

Figure 1. Ultrasound images of acetabular labrum in head-neck junction overresection state A) femur in full extension, labrum noted in yellow tracing; B) femur in flexion with labrum outlined in blue; C) TrakEM2 aligned overlay of extension and flexion images with maximum labrum tip displacement (red) and radial labrum tip displacement (orange)

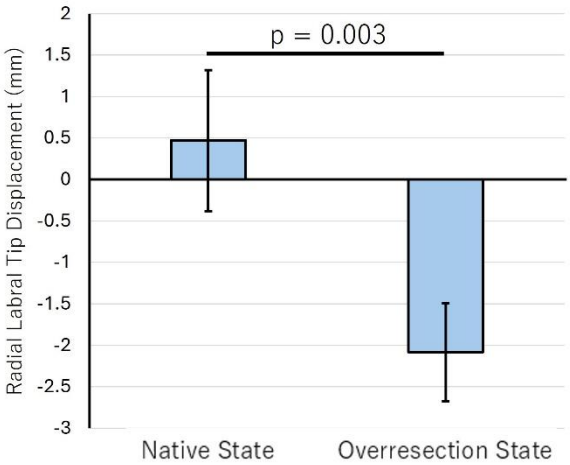

Figure 2. Radial labral tip displacement of the native state and the overresection state demonstrating significantly more inward radial displacement of the labral tip in the overresection state compared to the native state.