

The Biomechanical Evaluation of Shelf Acetabuloplasty in the Setting of the Iatrogenic Dysplastic Hip

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INTRODUCTION: Shelf acetabuloplasty has been described as a surgical treatment for developmental dysplasia of the hip (DDH) and has been gaining attention as a less invasive procedure compared to peri-acetabular osteotomy. Although favorable outcomes have been reported after endoscopic shelf acetabuloplasty, the biomechanical effect of shelf acetabuloplasty remains a topic of controversy due to the lack of evidence regarding the efficacy of the procedure in the setting of DDH. The purpose of this study was to evaluate the stabilizing effect of shelf acetabuloplasty in the setting of hip dysplasia.

METHODS: Ten fresh-frozen cadaveric hips with no evidence of prior hip surgery or pathology were dissected down to the hip capsule and mounted to a 6-degrees of freedom robotic arm. Each specimen underwent biomechanical testing in 4 states (*Figure 1*): 1) Intact, 2) Capsular repair, 3) Hip dysplasia model and 4) Shelf acetabuloplasty. For the capsular repair state, the capsule was detached from its acetabular rim 7 cm posteriorly from the anterior inferior iliac spine. Eight transosseous tunnels were created through the ilium, and the hip capsule was then repaired with four No.2 high-strength sutures passed through the tunnels. The capsule repair state was tested to serve as a control, because the capsule needed to be opened to perform the over-resection model and the shelf arthroplasty. This allowed the researchers to differentiate between laxity introduced by the bony changes and any potential soft tissue changes associated with disrupting the hip capsule. For the hip dysplasia model, the labrum was detached from the acetabulum, then the acetabular rim was then resected with a bone saw to achieve lateral center-edge angle (LCEA) of 15-20 degrees confirmed by a fluoroscope. The labrum was then re-attached with three suture anchors. The hip capsule was then closed using the same method as the capsular repair state. For the shelf acetabuloplasty, a tricortical bone graft (5 mm in height x 30 mm in width x 35 mm in length) was harvested from the iliac crest. Then, a slot (5 mm in height x 25 mm in width x at least 20 mm in depth) was created above the hip capsule. The bone graft was introduced into the slot using press-fit fixation to achieve LCEA of 35 - 40 degree confirmed by the fluoroscope. Biomechanical evaluation consisted of 4 robotic tests: 1) 5-Nm abduction, 2) 5-Nm internal rotation at 75° flexion, 3) 5-Nm flexion 4) 88-N Lateral Drawer. Primary outcomes were range of motion in degrees for the rotation tests and lateral displacement in mm for the lateral drawer test. A 1-factor random intercepts linear mixed effects model was established for each outcome. The effect of specimen state was determined using ANOVA, and all post-hoc pairwise comparisons were made between states, using Tukey's method to adjust for multiple comparisons.

RESULTS SECTION: The capsule repair showed no significant differences compared to native in any test. The Hip dysplasia model showed increased abduction (+2.3° p=0.003), and IR at 75° flexion (+0.9°, p=0.017), compared to native, and showed no increase in flexion or lateral translation. The shelf acetabuloplasty restored native abduction and IR at 75° flexion, but reduced hip flexion (-1.7° p=0.003).

DISCUSSION: The study examined the effectiveness of shelf acetabuloplasty in addressing hip instability caused by iatrogenic hip dysplasia. It found that shelf acetabuloplasty restored hip stability in terms of abduction and internal rotation to a level similar to native hips. No significant differences were observed between native and surgically altered states in terms of lateral translation of the hip. This study also developed a unique iatrogenic hip dysplasia model to create hip instability. This study is the first to demonstrate that shelf acetabuloplasty can improve hip instability in a developmental dysplasia of the hip (DDH) model through range of motion testing using human hip cadavers. The study had some limitations, including the use of fluoroscopy for radiographical measurements and lack of in vivo healing and loading effects.

SIGNIFICANCE/CLINICAL RELEVANCE: Shelf acetabuloplasty was shown to have a biomechanical benefit in the treatment of DDH, and may be considered as an alternative to PAO in some cases.

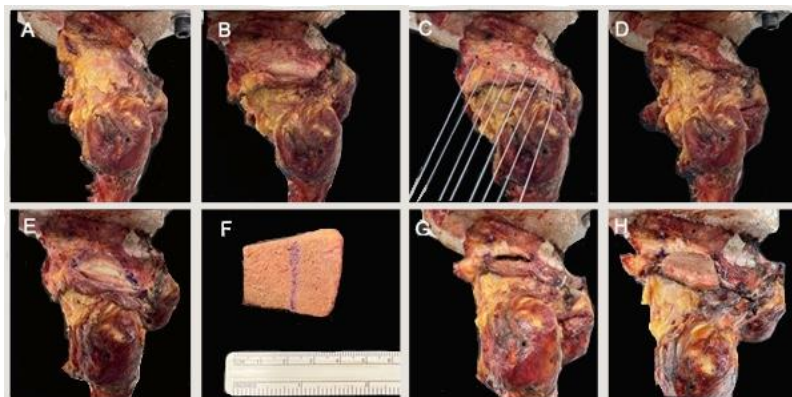


Figure 1: Surgical procedure (Left hip)
A) Native state. B) Capsule was detached from its acetabular rim. C) Transosseous tunnels were created for capsular repair. D) Capsule was re-attached with four sutures (capsular repair state). E) Labrum was detached and osteotomy was performed (Hip dysplasia model state). F) Shelf bone graft was harvested from iliac crest. G) Slot was created in ilium. H) Shelf bone graft was inserted into slot (shelf acetabuloplasty state).