Biomechanical Testing of Unstable Slipped Capital Femoral Epiphysis Screw Fixation - Should SCFE Be Reduced?

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Disclosures:  
M.R. Schmitz: 7; •Lecturer, Miller Review Course. C.L. Farnsworth: None. D.A. Glaser: 4; mako, Mankind, Alphatec. 5; EOS Imaging, Scoliosis Research Society, Growing Spine Foundation, KCI, K2M, Naval Medical Center San Diego, Pediatric Orthopaedic Society of North America. J.D. Doan: None. B.P. Scannell: None. E.W. Edmonds: 2; Arthrex, Inc.

Introduction:  
Slipped Capital Femoral Epiphysis (SCFE) is a common painful hip disease in adolescence which causes loss of mobility and decrease in activity, potentially resulting in progressive femoral head deformation and/or avascular necrosis (AVN). The condition occurs when the proximal epiphysis of the femur becomes disconnected from the metaphysis and “slips” through the open physis. Treatment goals include stabilizing the epiphysis, preventing further displacement, and avoiding the devastating complications of AVN and chondrolysis. Debate continues about the best manner to stabilize the physis. Surgical treatment of placing a screw (or screws) to hold the epiphysis onto the metaphysis in situ, without a reduction of the slip for fear of inducing AVN, is considered the gold-standard treatment. A pig model previously demonstrated greater biomechanical stability with use of two screws compared to one; however, single screw fixation was still recommended as the added stability of a second screw was minimal compared with the risk of complications. The previous study used an anatomically reduced SCFE model which does not necessarily replicate most situations of in situ fixation. The purpose of this study was to evaluate fixation strength of in situ pinning in unstable moderate slips with residual displacement compared to anatomically reduced slips with no displacement via either single or two screw fixation using a porcine model.

Methods:  
SCFE Model:  
Twenty 4-5 month old (70-80kg) pig femurs were acquired and radiographs performed to assure that anatomy was free from abnormalities (congenital or traumatic). A SCFE was created in each femur by cutting the periosteum over the proximal femoral physis and levering the epiphysis off of the metaphysis. The SCFE models were then placed into one of four treatment groups (n=5 each): pinned (3.5mm fully threaded pelvic cortex self-tapping screws, 60-75mm; Synthes, Monument, CO) with no displacement (one (Group N1) or two (Group N2) screws) or pinned with a moderate posterior-inferior displacement of 50% of the epiphyseal diameter using either one (Group D1) or two (Group D2) screws. Biplanar radiographs were taken to confirm pin placement and slip displacement; Figure A.

Biomechanical Testing:  
Biomechanical testing was performed using a biaxial servohydraulic table mounted MTS 858 Bionix machine (MTS Systems, Eden Prairie, MN). Both ends of the specimens (femoral heads and shafts) were embedded in polyester resin, then secured into custom aluminum fixtures. Femurs were aligned so that the applied forces were shear along the plane of the epiphysis. Each specimen was tested to determine fixation strength by cyclic antero-posterior loading through the femoral head until failure. Failure was defined as epiphyseal translation greater than one third of the physeal diameter. Cyclical forces between 40 and 200N were applied along each placement and slip displacement; Figure A.  

Results:  
One sample from each D1 and D2 did not complete testing due to fixation problems (n=4 for D1 and D2, n=5 for N1 and N2). Although the data show trends of greater mean Force Cycles with non-displaced over displaced (p=0.13) and with two screws over one (p=0.19), this is not significant with no interaction between the two (p=0.58). Number of Cycles to failure showed the same trends, also with no significant differences between non-displaced and displaced (p=0.10) and number of screws (p=0.13) with no interaction (p=0.64). Comparing only N2 and D1, Force Cycles was significantly greater in N2 (273,400±121,800N) than...
D1 (660,200±109,200N, p=0.0015) (Figure B). All samples failed through the epiphysis, except one femur in the D1 group which failed through the femoral neck.

Discussion:
There appears to be a trend toward requiring higher force cycles to achieve displacement of fixation in both the non-displaced groups and those fixed with 2 screws. Higher force cycles correspond to a greater strength of stability at the physis and thus decreased risk of subsequent displacement. We found no significant differences in testing single versus double screw techniques in both non-displaced and moderately displaced SCFE as a group. Yet, there was a significant difference between the non-displaced two screw fixation group and the displaced single screw fixation group. In conclusion, stability with in situ fixation of displaced SCFE was not augmented with reduction, especially if 2 screws are used for fixation. Within displacement groups, however, the addition of a second screw for fixation did not significantly increase the stability in our model.

Significance:
Non-displaced SCFE does not require a second screw; but, in situ fixation of displaced SCFE may be best performed with a second screw, although there is smaller margin of error for screw placement in this clinical setting.

Acknowledgments:
Rady Children’s Specialists Foundation Orthopedic Research and Education Fund for research support.

References:

ORS 2014 Annual Meeting
Poster No: 0872