BIOMECHANICAL ANALYSIS OF SINGLE SCREW FIXATION FOR SLIPPED CAPITAL FEMORAL EPIPHYSIS: ARE MORE THREADS ACROSS THE PHYSIS NECESSARY FOR STABILITY?

Introduction
Slipped capital femoral epiphysis (SCFE), a common hip disorder in the overweight adolescent population, is characterized by the displacement of the femoral epiphysis from the metaphysis through the physis. The goals of SCFE treatment are to prevent progression of the slip, while avoiding complications of avascular necrosis and chondrolysis. Regardless of the severity of the slip, in situ fixation is the standard of care, as it provides the best long-term function and is associated with the lowest risk of complications. However, fixation failures and slip progression can occur despite treatment, suggesting that current practices may be improved.

The purpose of this study was to evaluate the biomechanical stability of SCFE fixation with a single cannulated screw. Sixteen millimeter threaded screws were used in this study to evaluate whether compression across the physis, or the distribution of threads across the physis, was more important for fixation stability.

Methods
Thirty skeletally immature porcine proximal femurs were dissected and sectioned through the physis line to simulate an acute slip. A cannulated 7.3mm stainless-steel AO screw with distal 16mm thread (5 threads) of appropriate length was used to stabilize the slip. Femurs were randomized into five different groups depending on the number of threads that would be placed across the physis. Fluoroscopic imaging was used to advance the screw one, two, three, four, or five threads past the physis, so that there were six femurs in each group (Figure 1).

Results
This study found that SCFE fixation with a single 16mm threaded screw had significantly greater load to failure and stiffness when two or three threads were placed across the physis, as compared to one, four, or five threads (p<0.05) (Figures 2A/B). No significant differences were found when comparing the groups with one, four or five threads across the physis.

Failure modes were also recorded for each specimen. Figure 3 depicts the two mechanisms of failure, head plow and neck plow. All the specimens in group 1 failed by the screw plowing through the femoral head causing ejection or significant displacement, while all the specimens in group 5 failed by the screw plowing through the femoral neck, causing cantilever displacement of the head. In groups 2, 3, and 4 both methods of failure were seen, including compression fractures through the posterior metaphysis.

Discussion
In vitro biomechanical analysis of SCFE stabilization with a 16mm threaded screw, demonstrates that greatest strength and stiffness is achieved when 40% to 60% of threads engage the physis, with a significant decrease in stability when 80% or more threads cross the physis. We conclude, therefore, that an equal distribution (about 50%) of threads across the physis is more important for fixation stability, than achieving compression by engaging all threads within the physis.

Clinically, slip progression after screw fixation is a recognized phenomenon commonly seen in patients with underlying endocrinopathies and unstable acute-on-chronic slips. Optimizing purchase by having an equal number of threads on either side of the physis may decrease the incidence of slip progression, especially as the prevalence of obesity increases in the adolescent population. Likely, the “compression benefit” concept should be discarded and screws with greater thread length (32 mm or even fully threaded) should be used as too few threads in the epiphysis as well as too few in the metaphysis, both leading to decreased stability.

This study has certain limitations. First, we use an in-vitro porcine mechanical model with normal animal femora. This model uses a simulated acetabulum to apply load to the femoral head in a physiologically relevant posterior-inferior direction at 0.5mm/sec. Fixation failure was defined as ejection of the femoral head, fracture of the head or neck, or displacement of the femoral head greater than 10 mm from anatomic position.

Data for force (N) and displacement (mm) were sampled at 10Hz for the duration of the test. Stiffness (N/mm) was calculated from the load-displacement curve between 50N to 500N. Data for maximum load to failure (N) and stiffness (N/mm) were compared between groups using a one-way ANOVA and a post-hoc multiple comparisons test.

References

Affiliated Institutions
†Department of Orthopaedics, Children’s Hospital SD, CA
**Cincinnati Spine Institute, Cincinnati, OH

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