Introduction

In situ fixation of slipped capital femoral epiphysis (SCFE) is associated with the lowest risk of complications and the longest delay of degenerative arthritis. A single cannulated screw, centrally placed perpendicular to the physis, is recommended for fixation of a stable/chronic slip. However, the treatment of an unstable/acute slip remains controversial as conflicting data exists regarding the stability of one versus two screw fixation. In a 2005 survey of the POSNA membership 57% recommended the use of a single threaded screw, while 40.3% recommend two screws in the fixation of unstable SCFE.

Previous studies have evaluated single versus two screw fixations using various animal models, however contemporary screws have not been tested, and a physiologically relevant posterior-inferiorly directed load has not been used. In addition, an evaluation of different screw positions within the femoral neck has not been performed for SCFE fixation. The purpose of this study was to simulate an unstable SCFE in an immature porcine model to biomechanically evaluate the stability of in situ fixation as a function of the number of screws, and the position of screw placement within the proximal femur.

Methods

Twenty-four skeletally immature porcine proximal femora were dissected and sectioned through the physeal line. A thirty degree angular wedge was resected to simulate a mild unstable SCFE by creating a retroverted head. The specimens were then randomized into four groups of six femurs each (Figure 1). Synthes 7.3mm stainless-steel AO screws with 16mm thread were used in this study.

Kirschner wires were inserted in a retrograde fashion perpendicular to the physeal cut, and advanced through the femoral head to ensure optimal screw placement. Two-part epoxy resin was used to secure each femur in an MTS 858 testing machine (MTS, Eden Prairie, MN) vertically along the mechanical axis of the femur. Load was delivered to the femoral head by a simulated acetabulum in a physiologically relevant postero-inferior direction at 0.5mm/sec until failure fixation.

Data for force (N) and displacement (mm) were recorded at 10Hz for the duration of the test. Stiffness (N/mm) was calculated from the load-displacement curve between 50N to 500N. A 1x3 ANOVA was used to compare data for maximum load to failure (N), stiffness (N/mm) and load (N) at 2mm, 4mm, 6mm and 8mm of displacement between the three two screw configurations. A 1x2 ANOVA was used to compare data between single screw fixation and all three two screw fixations combined. Data was checked for normality and equal variances, and the level of significance was set at 0.05.

Results

When comparing between the three two screw configurations no significant differences were found in the average maximum failure load, average stiffness, or load required for each measure of displacement. Therefore, data from all two screw constructs were averaged and compared to single screw fixation. The average maximum failure load of all two screw constructs (1388.3±481.6 N) was 66% greater than the average maximum failure load of the single screw construct (917.9±262.8 N) (p=0.053). The average stiffness of all two screw constructs (190.7±56.84 N/mm) was also 66% greater than the average stiffness of the single screw construct (127.6±50.9 N/mm) (p=0.035). In addition while there was no difference at 2mm of femoral head displacement, each subsequent displacement (4mm, 6mm, and 8mm) demonstrated significantly higher failure loads in the two screw constructs (p<0.02 for all comparisons) (Figure 2).

Discussion

Primary treatment for SCFE aims to prevent slip progression while avoiding the complications of avascular necrosis and chondrolysis. A previous biomechanical analysis of single versus double implant fixation concluded that the slightly increased stability achieved by a two implant construct did not offset the increased risk of complications. Multiple implants were thought to increase the possibility of screw protrusion into the hip joint, and thus single implant fixation was recommended to reduce the risk of joint destruction and degenerative arthritis. Single screw fixation has become the standard treatment in patients with stable SCFE. However, its efficacy in acute/unstable SCFE has yet to be established as slip progression after in situ single screw fixation is a well recognized phenomenon.

In this study, two screw fixation was found to be significantly stiffer, and 66% stronger than the single screw construct. However, no significant differences were found among the three two screw configurations. Operative fixation of unstable SCFE may require the stability of two screws, especially with obesity on the rise in the adolescent population. As screw configuration was not an important factor in fixation stability, the stability of two screws in any orientation should be similar. Due to the technical difficulty of accomplishing this goal without violation of the hip joint with an implant, perhaps there is some role for image guided surgery. In our opinion, as shown in Figure 3, the oblique configuration facilitates placement of two screws within the small elliptical area of overlap between the epiphysis and metaphysis and ensures that both screw shanks are supported by cortical bone to prevent slip progression.

This study has certain limitations. First, we use an in-vitro cadaveric animal model with a simulated unstable slip; since no model exists that reproduces SCFE in vivo. Second, this model uses a simulated acetabulum to apply load to the femoral head in a physiologically relevant direction, but ignores any affect that surrounding structures such as the ligamentum teres may have on SCFE progression. Lastly, we use a load to failure algorithm in this biomechanical test which is different from the cyclic loading experienced by the hip in a post-operative patient.

Future studies should focus on varying the level of SCFE deformity to potentially optimize positioning of screw fixation. In addition, randomized clinical trials of single versus double screw fixation of an unstable slip are needed to evaluate clinical outcomes.

References


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