Biomechanical Evaluation of Locked Plating Fixation for Unstable Femoral Neck Fractures

***Emily Bliven, BS**; Simon Hackl, MD; Sabrina Sandriesser; Peter Augat, PhD*
Institute of Biomechanics, Trauma Center Murnau, Murnau, Germany

Purpose: Fractures of the femoral neck are commonly treated with multiple cannulated screws, compression hip screws, or proximal femoral locking plates. However, high complication rates are still observed, especially in vertically oriented and more unstable fracture cases. The purpose of this study was to evaluate if treating an unstable femoral neck fracture with a locking plate with spring-loaded telescoping screw system would improve construct stability compared to conventional fixation methods when loaded in a physiological fatigue scenario.

Methods: 30 fresh-frozen femur cadavers were evenly distributed into 3 groups based on bone mineral density (BMD) in the femoral neck. A 31B2 Pauwels type III osteotomy with an additional posterior wedge was cut into each specimen to simulate an unstable multifragmentary fracture. Specimens were implanted by fellowship- trained surgeons with either: 3 cannulated screws in an inverted triangle configuration (CS), a sliding hip screw and anti-rotation screw (CHS+1), or a locking plate with spring-loaded telescoping screw system. Only 2 out of 3 possible screws were utilized in the spring-loaded telescoping screw system. Constructs were mounted in a material testing machine and dynamic fatigue testing was conducted with physiological loads representative of walking with increasing weight bearing. Constructs were loaded until specimen failure or 15- mm actuator displacement was observed. Movement of the femoral head with respect to the shaft was recorded using a high-resolution optical motion tracking system. Statistical evaluation was performed using multivariate analysis of variance with Bonferroni correction and femoral head BMD as a covariate.

Results: Construct stiffness was 582 ± 344 N/mm and 509 ± 158 N/mm for the CS and CHS+1 groups, respectively, and 740 ± 371 N/mm in the spring-loaded telescoping screw group. CHS+1 and spring-loaded telescoping screw specimens failed at twice the average number of cycles as the CS group. Plastic rotation of the femoral head indicative of varus tilt was found to be 1.4 ± 1.4° in the CS group, 0.5 ± 0.6° in the CHS+1 group, and 0.2 ± 1.0° in the spring-loaded telescoping screw group during early stages of loading. Average femoral shortening at 6500 cycles was 2.2 ± 2.5 mm in the CS group, 1.5 ± 1.4 mm in the CHS+1 group, and 0.3 ± 0.5 mm in the spring-loaded telescoping screw group. The observed deformation values demonstrated statistical significance between spring-loaded telescoping screw and CS groups ($P<0.05$). A moderate correlation was found between femoral head BMD and construct stiffness ($r = 0.65$, $N = 30$, $P <0.001$).

Conclusion: Use of the spring-loaded telescoping screw system resulted in higher construct stiffness and lower plastic deformation of the femoral head with respect to the shaft during early stages of cyclic loading. This study's findings suggest that the spring-loaded telescoping screw system improves the biomechanical stability of unstable femoral neck fractures when compared to the CS method, and could be a suitable alternative to the use of a hip screw system. Confirmation of these results in a clinical setting is necessary.

See the meeting app for complete listing of authors' disclosure information.