

Supplemental Medial Column Screw (MCS) increases stiffness when compared to isolated lateral locked plating of Distal Femur Fracture in Osteoporotic Bone

Riley Davis¹, Fernando Ferrera², Nicholas Thomas², Gele Moloney², James Delullo², Kenny Koay³, James Hearn³, Seyed Hamid Reza Sanei⁴
¹Pennsylvania State University, Erie, PA, ²University of Pittsburgh Medical Center, Pittsburgh, PA, ³DePuy Synthes
Warsaw, IN, ⁴University of Missouri, Saint Louis, Mo
Presenting Author Email: rad5921@psu.edu

INTRODUCTION: In the geriatric population, distal femur fractures are common due to osteoporosis, where weakened and less dense bone are prone to fracture even under low energy impact. Open Reduction Internal Fixation (ORIF) is necessary to restore mobility and promote healing. The current gold standard is a lateral locking plate (LLP), and most widely used as a single fixation method. However, LLP is prone to failure, plate deformation, plate fracture, or screw backout due to lack of sufficient stability. These limitations led to the development of dual fixation systems, most commonly the double plate configuration, which combines an LLP with a medial locking plate (MLP). Additional alternatives have since been explored, such as LLP with an intramedullary nail or with a medial column screw (MCS). The biomechanical performance of these configurations is typically assessed through stiffness and fatigue testing, using both physical experiments on cadaveric or synthetic femurs and virtual finite element analysis. In this study, the LLP with MCS configuration was evaluated to determine its effectiveness compared to the lone LLP and the dual plate standard.

METHODS: In this study, both physical and virtual biomechanical testing were conducted on three implant configurations: standalone LLP, dual plate, and LLP combined with MCS. Physical testing was performed using an MTS 810 Tensile Machine. Custom-molded silicone grips were designed to secure synthetic femur specimens. The bottom grip was created with a partial silicone mold of the distal condyles, while the top grip incorporated a 3D-printed hemispherical disk embedded in silicone to hold the femoral head. This setup was developed to closely replicate *in vivo* boundary conditions at the hip and knee joints. Loading was applied through the femoral head along the mechanical axis of the model femur. Quasi-static compression was performed at a displacement rate of 0.25 mm/s, and stiffness was calculated from the linear portion of the force-displacement curve. Virtual testing was conducted using finite element analysis (ANSYS). A 3D femur model was obtained from BodyParts3D, and implant models were provided by DePuy Synthes Inc. (Warsaw, IN). The femur was segmented into cortical and cancellous regions, with orthotropic material properties assigned to each. Fixed boundary conditions were applied at the distal condyles, and a load of 700.71 N, a load is equivalent to the weight borne by the femur of a 315-lb patient during single-leg stance, was applied at the femoral head along the mechanical axis, with all contact surfaces set to bonded.

RESULTS: The stiffness of each configuration was determined from compression testing of the synthetic femur models. Among the groups, the standalone LLP demonstrated the lowest stiffness at 43.9 N/mm, followed by the dual plate configuration at 52.4 N/mm. The LLP combined with MCS achieved a slightly higher stiffness of 53.4 N/mm, indicating a viable alternative to double plating. In addition to stiffness testing, load-to-failure analysis was performed to characterize failure patterns. Preliminary results showed that periprosthetic failure proximal to the LLP was the predominant mode, consistent with patterns observed clinically. Finite element analysis of the lone LLP further revealed stress concentrations within the working length of the plate, ranging from 300–500 MPa (Figure 1), indicating that the plate stresses near its yielding limit and supporting a need for supplemental fixations.

DISCUSSION: The standalone LLP demonstrated the lowest stiffness among all configurations, consistent with the established understanding that dual fixation provides superior stability. The LLP with MCS configuration achieved stiffness equivalent to the dual plate construct, supporting its potential as a viable alternative. While these preliminary results support the study hypothesis, further evaluation, particularly under cyclic loading, is needed to confirm long-term effectiveness.

SIGNIFICANCE/CLINICAL RELEVANCE: The comparable stability of MCS fixation to double plating highlights its potential as a superior alternative, offering shorter operative time and reduced risks of complications such as blood loss and infection. For geriatric patients with poor bone quality, MCS provides a less invasive and safer option than double plating, while maintaining mechanical stability necessary for early mobilization.

