INTERFRAGMENTARY LAG SCREW FIXATION REDUCES RESULTING SHEAR MOVEMENTS IN SIMPLE FRACTURE PATTERNS

Mark Heyland (1), Werner Schmölz (2), Georg N. Duda (1), K.-D. Schaser (3), Sven Märdian (4)

1. Julius Wolff Institute, Charité – Universitätsmedizin Berlin, Germany; 2. Department of Trauma Surgery, Medical University of Innsbruck, Austria; 3. Universitätsklinikum Carl Gustav Carus Dresden an der TU Dresden, Germany; 4. Center for Musculoskeletal Surgery, Charité – Universitätsmedizin Berlin, Germany

Introduction
Minimal invasive techniques with locking plates for elastic bridging are part of modern fracture care, especially for osteoporotic bone stock and comminuted fractures [1,2]. When a longer plate working length is chosen, stiffness decreases and resulting shear movements increase disproportionally. This might be compensated by an additional lag screw as it increases stiffness of bridging locking plate constructs especially in torsion [3]. For simple fracture patterns, an additional interfragmentary lag screw may lead to faster healing through higher stiffness and improved fracture stability [3,4,5]. We evaluated the influence of a plate independent interfragmentary lag screw perpendicular to the fracture line on the resulting motion directly at the fracture site in a simple fracture model at the distal femur subsequently stabilized with a locking plate.

Methods
Paired human femora (N=2x5) were derived from the local Department of Anatomy at Innsbruck and tested in on-site facilities. All donors gave informed consent prior to death. A locking plate (LCP-DF, Synthes) was placed to the distal femur (7 screws). Embedding was performed using poly-methyl-methacrylate cement. All specimens sustained a simple fracture (33-A1.1) through a 45 degree osteotomy in the sagittal plane at the metaphysis. This was anatomically reduced and a 4.5mm interfragmentary lag screw was inserted perpendicular to the osteotomy plane (group A) prior to establishment of proximal plate fixation which was performed using four locking head screws (bicortical). Specimens of group B were prepared in the same way without inserting a lag screw following anatomical reduction. After testing of groups A and B, the most distal locking screw of the proximal plate fixation (first screw proximal to fracture level) was removed and the test protocol was repeated. Specimens underwent quasi-static testing (MTS 852 Mini Bionix II) of torsion (internal/external, 2Nm/4 Nm, 4deg/min) and axial compression (500N/1000N, 0.5mm/sec) using adapted boundary conditions [3]. Each test consisted of five load cycles (first cycle neglected). Motion was recorded using the validated optical measurement system PONTOS 5 M (GOM) with an accuracy ≤ 5μm [6]. Interfragmentary movement (IFM) was calculated neglecting deformation. The relative motion (difference of position without and with loading) of proximal and distal fragment was calculated through minimization of squared sum of distances of all marker positions to reference point positions. Normal movement (positive = compression) is defined as the relative movement orthogonal to the fracture plane while shear is the vector sum of the movement in the other two directions.

Results
An additional lag screw next to locking plate fixation reduces IFM (Figure 1) for different loads and different plate working lengths. After anatomic reduction, normal IFM is small especially in torsion. Shear movement is larger and a lag screw reduces it in all tested cases.

Discussion
Locking plate fixation is the gold standard for fixation of metaphyseal long bone fractures. In simple fracture patterns, interfragmentary lag screws provide a tool to decrease IFM, especially shear motion that has been shown to inhibit fracture healing [7].

References