Axial and Rotational Mal-Reduction (Golf Club Deformity) in Distal Femur Fractures.

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Introduction: Open reduction and internal fixation of fracture have helped trauma patients to mobilize early for decades. The procedure helped in restoring the limb mechanics to close to their original state. Precontoured lateral condylar locking plates have been increasing in popularity as a method for stabilizing distal femur fractures since their development. They provided an edge to other methods by accounting for the natural contour of the distal femur. But despite their advantages, some studies have shown associated malunion rates between 11-26%.ref A specific problem in recent years have been described as a malreduction and medialization of the articular block, sometimes referred to as golf club deformityref. The purpose of this study is to define the so called “golf club deformity” and test a hypothesized solution. The authors hypothesize that the golf club deformity is a combined medial translation and axial external rotation which occurs when the plate is placed using current methods, and that placing the plate in a better anatomic position by placing it in 10° of external rotation, thus accounting for the normal slope of the lateral distal femoral condyle should lower the malunion rates.

Methods: A supracondylar distal femur fracture model was created (AO/OTA 33A) using 7 fresh frozen cadaver femurs. All femurs were radiographed prior to testing to insure no previous fractures. An eight hole, lateral distal locking femoral plate (Stryker® AxSOS Mahwah, NJ) was placed flush to the lateral femoral condyle (Group I) and then reduced to the shaft (figure 1). In (Group II) the anterior flange of the plate was external rotated 10 degrees in relation to the lateral condyle (figure 1). Optical motion capture (Max Pro® optical tracking system, Innovision Systems®; Columbiaville, MI) measured translation and rotation of the articular segment as screws were tightened and the plates were reduced to the femoral diaphysis. Since both configurations were applied to each bone, paired Student t-test was used to compare the differences in measures of malreduction.

Results: Average medial displacement of the articular block was 17.1 ± 10.4mm vs. 9.3 ± 4.7mm for groups I and II respectively (p=0.02). Therefore, the average reduction in medial translation from group I to group II was 7.8 ± 6.8mm. Plate external rotation in Group II improved medial translation by 46%. Average anterior displacement was 6.0 ± 4.3mm vs 2.1 ± 1.2mm for groups I and II respectively (p=0.08). Therefore, the average reduction of anterior translation was 3.9 ±4.9 mm and represented a 65% improvement in sagittal plane translation. Average external rotation was 12.2 ±3.6 degrees vs 2.5 ± 2.0 degrees for groups I and II respectively (p=0.002). Therefore, the average reduction of axial external rotation was 9.7 ±4.7 degrees. This represents an 80% improvement in axial mal-rotation.

Discussion: Data presented here demonstrates significant medial translation (17mm) and external rotation (12.2°) despite appropriate plate placement, as described by Collinge et al and Kregor et al.
supporting our hypothesis that there might be a mismatch between plate design and the anatomy of distal femur. Placing the plate in 10° of external rotation was noted to largely, but not completely, correct the malalignment. Unfortunately, a persistent medial translation of 0.9 cm was observed with the 10° external rotation group suggesting the need for further studies. In light of that, the authors turned to large database to confirm the anatomic alignment of the lateral femoral (Stryker® Orthopedic Modeling and Analytics technology “SOMA”). This database allowed systemic measurement of the lateral distal femoral condyle of 800 femurs, and the results showed that the angle of the lateral distal femoral condyle has a mean posterior anterior inclination of 16.5° (figure 2).

**Significance:** This study looked at precontoured lateral condylar locking plates with malunion rates of 11-26% hoping to improve on them, and although the results show great improvements, a lingering 0.9cm of medial translation was observed. Future studies will investigate other means of correcting the malalignment, especially considering the 16.5° posterior anterior inclination of the condyle.

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**Figure 1:** Photos of a specimen from each group. A) Group I illustrates placement of the distal foot print flush to the lateral cortex (white arrow). B) Group II demonstrates external rotation of the distal foot print as indicated by the anterior flange sitting off the lateral cortex (white arrow).

**Figure 2:** 3-D model showing the average degree of the distal femur inclination

ORS 2015 Annual Meeting

Poster No: 0646