ISAKOS

International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine

9th Biennial ISAKOS Congress • May 12-16, 2013 • Toronto, Canada

Paper #61

Opening Wedge Distal Femur Osteotomy: Biomechanical Study of a Biplane Fixation Using Conventional Implants

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Summary:
Osteotomy models were created in composite replicate femurs, fixated with two different plates, and compared its axial and torsion stiffness. Biplane fixation models were created with conventional plates and one 6,5mm cancellous screw inserted in the medial side in a different plane, increasing the axial/torsion stiffness. Biplane fixation stiffness was greater than standard locking plate.

Abstract:
The medial cortex integrity is very important in the opening wedge distal femur osteotomy for genu valgum. It ensures greater stability and helps bone healing. The failure of the medial cortex can occur during the surgery, when the stabilization is necessary, or during the follow up, before the bone callus enables loads, with risk of correction loss. We propose a new technique, performed with low cost implants and increased stability, and no add to operative time or surgical morbidity. This study analyzes the biomechanical stability provided by two different implants, one conventional plate and one standard locking screw plate created to this type of osteotomy.

Osteotomy models were created in distal third of composite replicate femurs, (SYNBONE® 2200, Malans, Switzerland). An open wedge was created in the lateral side of the femurs, 50mm above the distal part of lateral condyle, converging 10mm before the medial epicondyle of the femur. The models were fixated by either on of two different implants: A 5 hole 60 mm 95º blade plate (Synthes®, Oberdorf, Switzerland), or TOMOFIX® (Synthes®, Oberdorf, Switzerland). The plates implanted according to the standard surgical procedure for each implant provided by the manufacturer.
Five groups were created. Two groups with TOMOFIX plate: the first kept the medial cortex intact, the second group a failure of 10mm was created in medial cortex, simulating the breakdown of medial cortex. Tree groups with 95º blade pate: The first group kept the medial cortex intact; on the second group the medial cortex was disrupted, creating a gap of 10mm. The third group also had a gap of 10mm in the medial cortex, one 6,5mm cancellous screw fully thread was inserted in a different plane of the blade plate, crossing the osteotomy from anteromedial to posterolateral, 20mm above the medial gap, at an inclination of 45 degrees to the shaft, providing a biplane fixation of the osteotomy.

Each sample was tested on the INSTRON 8872® compression device (Instron, Norwood, MA), limited to static axial load of 1500N with 0º of anatomic axis of the femur, and tested on the INSTRON 55MT® torsion device (Instron, Norwood, MA), limited to 7Nm of external rotation. Theses loads simulate a normal walking of a 75kg patient.

The groups fixed with TOMOFIX showed the following results: group 1 (intact medial cortex) showed the mean axial stiffness of 1001 N/mm2 (SD: 1101, MAX: 1246 MIN: 939.2), and mean torsion stiffness of 2319N.mm/degree (N.mm / Nº) (SD: 255.7, MAX: 2589, MIN: 1932). GROUP 2, (medial cortex disrupted), showed a mean axial compression stiffness of 710.6 N/mm2 (SD: 73.69, MAX: 821.1, MIN: 592.5), and an mean torsion stiffness of 1721 N.mm/º (SD: 189.7, MAX: 1910, MIN: 1419).
The groups fixed with 95 ºblade plate showed the following results: group 1, (intact medial cortex), showed mean

axial compression stiffness of 1037 N/m (SD: 68.95, MAX: 1180 MIN: 921.9) and mean torsional stiffness of 2416 N.mm/° (SD: 232, MAX: 2874, MIN: 2101). GROUP 2, (medial cortex disrupted) showed the mean axial stiffness of 671.8 N/m (SD: 46.08, MAX: 779.9, Min: 618.3) and mean torsional stiffness of 1973 N.mm/° (SD: 173.2, MAX: 2232, MIN: 1764). GROUP 3, (medial cortex disrupted, screw fixed), showed mean compression axial stiffness of 893.7 N/m (SD: 59.95, MAX: 976.5, Min: 786.3) and mean torsion stiffness of 2236 N.mm/° (SD: 150.6, MAX: 2502, MIN: 2004).
Comparing the groups which intact medial cortex, the construction with TOMOFIX (TOMO) showed an axial compression stiffness slightly greater than the 95º blade plate (PL5), however without statistical difference. The torsion stiffness was similar between the two groups.

The comparison between groups with failure of medial cortex TOMO and PL5 showed similar stiffness to axial compression, without statistical difference. However, the torsional stiffness was higher in groups fixed with PL5 ($p < 0.05$). Biplane fixation, with anteromedial screw stabilization provide a greater axial and torsion stiffness than PL5 alone comparing the 95º models with failure of the medial cortex. There was an increase in the compression stiffness of 33%, the torsion stiffness of 13.3% ($p < 0.05$). Also, axial and torsion stiffness of the biplane fixation were greater than TOMO ($p < 0.05$).

In our biomechanical study, the 5 hole 95º blade plate showed the same axial compression stiffness than TOMOFIX, but greater in torsion. The 95 degree blade plate is a strong fixed angle plate, but is non-locked, made of steel, was created initially for the treatment of fractures, and later began to be used for osteotomies. TOMOFIX is a locked plate, made of titanium, and was created specifically for the fixation of osteotomies.
Blade plate and cancellous screw is a low cost and cost-effectiveness system of fixation. The screw stabilization of the medial cortex was inserted from proximal to distal, and anteromedial to posterolateral, along with lateral plate configures a biplane fixation. We believe this helps improving the stiffness of the setting. When inserted one anteromedial screw, models fixed with blade plate showed an increase in axial and torsion stiffness, overcoming the TOMOFIX.
This screw can be passed in percutaneous way during the surgical procedure, without adding any morbidity, or significantly time increasing to the procedure.
It should be noted that the possibility of failure of opposite cortex in opening wedge osteotomies is intrinsic to the procedure, further failure could also occur during the clinical follow-up. Thus any system of fixation must be designed to support this scenario.

Biplanar fixation provided by the addition of an anteromedial screw with 95º blade plate fixation increases the axial and torsiin stiffness on models of lateral opening wedge distal femur osteotomy of the third distal femur, overcoming the TOMOFIX.