BIOMECHANICAL ANALYSIS OF SUPRACONDYLAR FEMORAL FRACTURES FIXED WITH LISS AND INTRAMEDULLARY RETROGRADE NAILS

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Introduction
The treatment of complex supracondylar fractures of the femur with internal fixation devices such as plates or a retrograde nail has gained wide acceptance. The retrograde nail system (ACE-A.R.T, De Puy) and the Less Invasive Stabilisation System (LISS, Synthes), monocortical fixation with locked screws, represent two technologies to fix this type of fractures. In these fractures the loss of fixation (‘windshield wiper effect’) after mobilisation presents a challenge to fracture fixation.

The aim of the study was a physiological biomechanical comparison of these two contrary fixation techniques and the abilities of both implants.

Materials and Methods
Twelve pairs of human cadaver femora were evaluated for bone density and classification by Dual Energy X-Ray Absorption (DEXA) scanning. Before the operation, a one-centimeter gap was cut parallel to the knee baseline, at a defined distance to the distal end of the femur to mimic an extra-articular supracondylar femoral fracture (Type 33-A3, AO/ASIF classification). Randomly selected paired femora were instrumented with a Synthes five hole LISS plate and a DePuy retrograde nail system ACE to form a Bone Implant Construct (BIC). The retrograde intramedullary nail system (ACE-A.R.T.) was locked through the two most proximal and distal holes according to manufacturer specifications. All nails measured 10mm in diameter and 320mm in length. The stabilized bone fragments were embedded (PMMA, Beracyl) in a cup simulating ‘physiological’ conditions (Fig.1). The femoral implant constructs were mounted on a uniaxial compression testing machine. Load was applied proximally through the ‘head’ of the femur. Optical displacement transducers (micro laser sensors, Matsushita Automation Controls, Switzerland) were fixed to the construct to measure changes in gap displacement while loading. The cyclic load applied was increased in six steps of five cycles at a rate of ±20N/sec each up to maximum loads of $F_{max}=250N$, 500N, 750N, 1000N, 1500N and 2000N starting with a constant load of $F_{min}=50N$.

Results
A clear difference in permanent deformation was observed with regard to the transverse displacement in the fracture gap of both fixation concepts. In all paired tests, LISS showed a lower tendency of permanent displacement, especially at high loads, whereas both techniques were comparable at low loads (Fig.2 and 3).

Discussion
The biomechanical investigation showed that LISS (monocortical plate fixation with locked screws) withstood permanent deformation in the transverse plane better than ACE (retrograde nail system). Regarding the axial deformation, the LISS BIC showed a higher tendency to elastic deformation due to the bending behavior of the plate, especially at high loads (Fig.3D). It is obvious that by using monocortical screws with angular stability in the plate, LISS can withstand a possible permanent displacement of fragments thanks to the fixation between cortex and anatomically preshaped plate. The retrograde nail system ACE, however, shows excellent transverse stability at lower loads, but at high loads the ACE BIC undergoes more deformation because no locked stabilization exists between nail and cortex. This behavior of ACE BIC can be explained by the fixation technique. Transverse displacement occurs whereas the so-called telescoping effect is prohibited by the interlocking screws (Fig.3C). The high transverse displacement is a result of missing angular fixation possibilities between the nail and the locking fixation bolts and an imperfect alignment in the medullary canal of the femur.

Conclusion
The tested LISS BIC showed less permanent transverse displacement especially at cyclic loads of more than 1000N than the ACE BIC.

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