BIOMECHANICAL INVESTIGATION OF LOCKED VS. NON-LOCKED DIAPHYSEAL FIXATION OF PLATE
SCREW CONSTRUCTS IN A NON-OSTEOPOROTIC HUMAN CADAVERIC DISTAL FEMORAL FRACTURE
MODEL

*Ricci, W M; **Tornetta, P; ***Zheng, Y; ***Walker, Z; ***Anthony, M; ***Holbrook, J
*Washington University School of Medicine, St. Louis, MO. ***Smith & Nephew, Inc., Memphis, TN
yanming.zheng@smith-nephew.com

INTRODUCTION:
Traditional (non-locked) plate screw constructs rely upon friction
between plate and bone for construct stability and are particularly
subject to loosening during cyclic loading in osteoporotic bone. New
locked plate devices, where the screw head securely locks into the plate,
do not require such friction for construct stability, and therefore are
thought to be beneficial in osteoporotic bone. The mechanical
properties, failure modes, and potential advantages and disadvantages of
such locked devices in non-osteoporotic bone, however, remain
unknown. The purpose of this study was to directly compare locked
plating constructs with locked and non-locked diaphyseal fixation in
non-osteoporotic bone under a physiologic cyclic loading condition in a
cadaveric distal femoral fracture model. Specifically, differences in
construct stability, load to failure, failure mode, and screw loosening
were studied.

METHODS:
Five matched pairs of human cadaveric femurs (bone mineral density
(BMD) 0.864-1.194 g/cm²) were harvested for this study. The left and
right femurs of each pair were randomly assigned into two groups of
locked and non-locked diaphyseal fixation. All bones were instrumented
using locked plates (PERI-LOC Distal Femur Locked Plating System,
Smith & Nephew, Memphis, TN). An extra-articular metaphyseal
fracture with a 3 cm gap simulated a comminuted fracture. Each plate
was first clamped flush to the bone to ensure that no gap existed between
the plate and bone upon instrumentation. Then, with the clamp still in
place, the screws were inserted and tightened to 3.96 N-m of torque at
the proximal and distal ends of the femur. Distal fixation in both groups
was achieved by use of five 5.7 mm cannulated locking screws.
Proximal (diaphyseal) fixation was achieved by use of either four 4.5
mm locked screws (LD) or four 4.5 mm non-locked screws (NLD) in the
closest and farthest holes from the fracture (Figure 1). After
instrumentation, the femur was cut below the lesser trochanter and
potted in Fast Cast such that plate motion was not restricted. All
specimens were subjected to an axial cyclic compressive load of 50
N/500 N (half body weight) with a physiologic varus moment at 2 Hz
for 500,000 cycles. Construct stiffness was evaluated initially and
subsequently at each 50,000 cycles. After 500,000 cycles, load to failure
and screw removal torque were measured. Statistical analysis was
conducted using a paired Student’s t-test.

RESULTS:
Non-locked constructs showed either similar or higher average
stiffness values at each of the 50,000 cycle intervals in comparison to
locked constructs (Figure 2). The load to failure of the non-locked
construct was higher than the locked construct for each cadaveric pair.
The average load to failure was 11% greater for the non-locked group
(Figure 3). However, the difference in load to failure between the non-
locked and locked group did not reach statistical significance (P=0.12),
which may be attributed in part to the variance in BMD of one sample
pair. For both the non-locked and locked groups, the screws nearest the
fracture gap exhibited the lowest extraction torque (greatest reduction
from insertion torque). The mode of failure observed was plate
deformation in all specimens.

DISCUSSION:
When tested under conditions of physiologic cyclic loading in non-
osteoporotic human bone, non-locked diaphyseal screw fixation
exhibited equivalent or higher average stiffness values and load to
failure compared with locked diaphyseal screw fixation. Under such
loading conditions in non-osteoporotic bone, the screws nearest the
fracture gap were most stressed as evident by the low screw removal
torque of these screws. These findings indicate that the use of non-
locked diaphyseal screw fixation associated with the new locked plate
devices may be advantageous in non-osteoporotic bone.

**Boston University Medical Center, Boston, MA.