INTRODUCTION:
Supracondylar femur fractures represent 6% of all femur fractures [1]. The surgical treatment of supracondylar femur fractures remains challenging especially when associated with comminution due to high rate of failure of fixation, more commonly in the setting of osteoporosis. Currently, periarticular distal locking plates have been preferred over the retrograde intramedullary nails (IMN) in case of severe comminution. Recently, a new IMN with distal interlocking screws locked to the nail has been developed in order to improve distal fixation; however biomechanical fatigue performance has yet to be investigated. The goal of this study is to determine the in situ fatigue strength of the new distal locking screw IMN for comminuted supracondylar femur fracture model (AO/OTA type 33A3) simulating 8 weeks of full weight bearing gait loading.

METHODS:

Specimen Preparation
Thirteen pairs (N=26) fresh frozen cadaveric femurs (2 male, 80.2±10.5 years old) were obtained from donors with no history of trauma. One femur from each pair was repaired with a locked IMN while the contralateral side was either repaired with a LP or non-locking IMN. A distal locked IMN, a non-locked IMN, or a locked plate (LP). The distal locking screws, 4 total, can be locked to the IMN or left unlocked as in conventional IMN (Biomet Trauma, Parsippany, NJ). Then, a gap was created simulating a metaphyseal fracture with comminution (AO/OTA type 33A3) [2] (Fig. 1). The proximal and the distal fragment were potted in a rigid plastic pipe and a polymer casting agent (SmoothOn, Smooth-On, Easton, PA) leaving the fracture site and distal interlocking screws unaffected.

Biomechanical Testing

The loading conditions simulated forces along the length of the femur during walking [3]. Specimens were cyclically loaded from 0.1 to 1.5 times body weight (BW) axially, 0.1 to 0.5 BW laterally, and 0 to 0.02 BW-m of external rotation at 4 Hz [3]. Every 25,000 cycles the axial load increased by 110N and the torsional load increased by 2Nm until failure. These loads were applied via a custom-designed test jig mounted to an axial-torsional test frame (MTS Mini-Bionix 858) (Fig. 2). This jig consisted of a torsional-locking bearing that converted the axial displacement of the test actuator into combined axial and shear loading. The testing set-up was validated on anatomical models (4th generation composite femur, Sawbones) and an in-line mounted multi-axial load cell (AMTI MC5-6-5000).

The integrity of the repair construct was assessed at regular intervals during fatigue testing. 16 cycles of data were recorded every 2500 cycles using the in-line load cell and the relative 3-D motion across the fracture site was also recorded (Optotrak 3020 with First Principles Software, Northern Digital, Inc) (Fig. 2).

The fatigue strength of the new distal locking IMN was compared to the traditional non-locking IMN and LP using the following outcome measures: 1) changes in the axial and torsional stiffness of the repair construct with fatigue loading; 2) Axial and rotational displacement at key cycle intervals; 3) number of cycles to acute failure; 4) mode of failure.

RESULTS:
The locked and non-locked IMN failed at 76,400±30,000 cycles and 56,600±24,200 cycles, respectively, but were not statistically different. The LP failed at 12,800±1100 cycles, which was significantly lower than the locked and non-locked configurations.

DISCUSSION:
The locking nail and non-locking nail offer a benefit of longer life than the locking plate, however they do not provide the torsional stability the plate can support in a multiaxial cadaver model. The LN trended towards more cycles to failure than the NLN and also trended to be stiffer in torsion. These were not statistically different, but may become significant with larger sample sizes.

REFERENCES: