INTRODUCTION:
Fractures of the tibial plateau account for nearly 10% of fractures in the elderly and 1% of fractures in the general population (1). There is a trend in fracture surgery to use synthetic osteoconductive biologics, particularly the calcium phosphates, for metaphyseal defects in order to improve the structural integrity of the fracture repair. Although the load-to-failure characteristics of calcium-phosphate augmented repairs have been investigated, the fatigue strength of repaired tibial plateaus has not been well characterized (2). Fatigue strength has implications in terms of immediate weight bearing capabilities. The goal of this study was to compare the biomechanical fatigue strength of calcium phosphate vs. autograft augmentation in the lateral tibia plateau with a split-depression fracture type under simulated physiologic loading conditions. The specific aims were: 1) to determine the difference in articular depression when loaded under physiologic conditions 2) to determine the maximum sustainable load prior to failure of the tibia fracture fixation construct, and 3) to determine whether there are clinically significant differences in the failure characteristics of the two fixation techniques. It was expected that calcium phosphate augmented repairs would provide a stronger, more stable repair than those augmented with autograft.

METHODS:
8 matched pairs of tibias (6 M, 2 F; age 75±14) were harvested from fresh frozen cadavers. Reproducible split-depression fractures were simulated and repaired by an orthopaedic traumatologist using a lateral tibial plateau plate (3.5mm, Synthes). One tibia from each donor was randomly assigned to either calcium-phosphate (Callos, Skeletal Kinetics) or autograft as augmentation. The femoral component of a hemi-total knee replacement was attached to the actuator of a servo-hydraulic press, and centered above the repair site. Cyclic, physiological compression loads were applied at 4Hz, starting with a maximum load of 15% bodyweight (BW), and increasing by 15% BW every 70,000 cycles. Loading conditions were determined from calculations of weight distribution, joint contact area, and gait characterization from existing literature (3,4,5). Fragment depression and stiffness was measured at regular intervals. Fragment depression was measured using a dial indicator which was mounted to the test frame (Figure 1). Stiffness was calculated by taking the slope of a least squares regression line fit to the force – displacement curves output by the testing machine. Specimens that survived fatigue loading were then loaded to failure at 1 mm/min.

RESULTS:
Calcium-phosphate augmented repairs subsided less (Figure 2) and were more stiff (Figure 3) during the fatigue loading than autograft at the 70k, 140k, and 210k cycle intervals (p<0.03, all measures, paired t-tests).

DISCUSSION:
Calcium-phosphate augmented repairs demonstrated significantly higher fatigue strength and ultimate load than autograft augmented repairs. These results suggest that calcium-phosphate augmentation may increase the immediate weight-bearing capabilities of the repaired knee. A strength of this study was that loading conditions were based on physiologic gait and incorporated factors including specimen body weight and the surface area of the load distribution through the hemi-total knee replacement. Exclusion of healing is the main limitation of this study. Because autograft is meant to heal before bearing any loads, this study could only address the immediate load-bearing capabilities of the repair construct. It is likely that a fully healed autograft repair would show a higher ultimate load, higher stiffness, and reduced amounts of depression. However, the results of this study can still be used to draw clinically relevant and important conclusions regarding the biomechanical properties of the different augmented repair constructs immediately post-op and during the 4-6 week healing period.

REFERENCES: