ABSTRACT INTRODUCTION:
Approximately 581,000 knee replacements are performed in the United States each year. Micromotion at the bone-cement and cement-implant interfaces causes bone resorption and loosening of the prosthesis. Aseptic loosening of the tibial implant is a prevalent reason for failure in Total Knee Arthroplasty (TKA). The cement viscosity at the time of application to the bone is vital for cement penetration and mechanical stability of the construct. High viscosity cements greatly reduce operating time, yet, may result in decreased penetration into the bone and reduced stability. It is hypothesized that this positive feature comes at the expense of decreased penetration into the bone and reduced stability of the construct. Micromechanics of implant-cement-bone composite interdigitization is investigated using a controlled biomechanical testing and digital image correlation. Twelve Sawbone models were instrumented with Zimmer NexGen-LPS tibial plates and fixed with one of four cements of differing viscosities: Simplex-P, Endurance, DePuy II, and Palacos (n = 3). The constructs were subjected to cyclic compressive loading (600 N) in the sagittal plane of the tibial implants for 6000 cycles. After cyclic loading, the constructs were loaded to 3000 N at the rate of 20 N/s using MTS 810 Testing Machine. Digital Imaging Correlation (DIC) was used to determine displacements between image frames taken from a fixed CCD camera. These techniques allowed the transverse and sagittal-plane micromotions to be quantified. Simplex had the smallest micromotion of all cements in sagittal plane (n = 3, P = .002 vs. Palacos and Endurance, and P = .2794 vs. Depuy-2). In transverse plane, Simplex had the lowest micromotion (0.0234mm±0.0175mm, n = 3, P = .011 vs. Endurance; P > .2 vs. Depuy-2 and Palacos). There was no statistically significant difference among cements when comparing maximum force at failure and composite stiffness. These results have direct clinical relevance for TKA patients suffering from aseptic loosening.

METHODS:
Twelve surrogate Sawbone constructs instrumented with Zimmer NexGen-LPS tibial plates and stabilized with four cements of different viscosities: SimplexP, Endurance, DePuy-II, and Palacos were subjected to cyclic compressive loading (600 N) in the sagittal plane of the tibial plates for 6000 cycles and then loaded to 3000 N at a rate of 20 N/s, using MTS 810 Testing Machine (MTS, Eden Prairie, MN). Force and axial-displacement were recorded. A CCD camera (JAI Pulnix TM1327 GE) was utilized to sequentially image the speckled tibial plate to determine micromotion of the tibial plate in transverse plane. Digital Imaging Correlation (DIC) software (RapidCorrelator v1.0) was used to measure displacements between image frames. A two tail t-test was used to determine the statistical significance of the results.

RESULTS:
Simplex exhibited the smallest micromotion of all cements in sagittal plane with a strong statistical significance when compared with Palacos and Endurance (n=3, P = .002, Fig. 1). The correlation was not significant when compared with Depuy-2 (n=3, P = .278). Figure 2 shows the DIC for one of the samples. DIC demonstrated that in transverse plane, Simplex had the lowest micromotion (0.0234mm ± 0.0175mm) with strong statistical significance when compared with Endurance (n = 3, P = .011, Fig. 3). There was no significant correlation with Depuy-2 and Palacos (n=3, P > .2). Palacos exhibited the maximum stiffness based on force-displacement curve (Fig. 4). However, there was no statistical significance when compared to Simplex (P > .2).

DISCUSSION:
Simplex, a low viscosity cement, exhibited the least micromotion in transverse as well as sagittal planes. High viscosity cement demonstrated higher construct stiffness. Flexural and axial rigidities combined with load sharing of cement mantle may play a role in long term stability of the cemented implants. The outcomes of the study have direct clinical relevance for the patients treated for total knee replacement surgery by reduction in revision surgeries due to aseptic loosening.