INTRODUCTION
The severity of knee osteoarthritis (OA) is multi-factorial, and is subjectively assessed based on self-reported pain and function. The objective assessment of knee OA may include radiographic and other measurements; however, functional status of the knee may not always correlate with the radiographic findings. Kinematic and kinetic measurements from three-dimensional gait analysis could provide additional valuable information regarding lower extremity mechanics. The goal of this work was to assess the value of several kinematic, kinetic, and radiographic variables as tools to measure the severity of varus knee OA and the efficacy of valgus bracing therapy. We hypothesized that several kinematic, kinetic, and radiographic variables will correlate with knee pain during stair ascent/descent at baseline and following one year of valgus bracing.

METHODS
Seven varus knee OA patients (4 males and 3 females, 66.9 ± 8.2 yrs, 81.4 ± 8.0 Kg, 1.7 ± 0.1 m) with substantially greater symptoms in one knee (> >3 on a 10-point Likert scale, Kellgren-Lawrence grade 2 to 4) than the other (< 3 points) were selected. No other conservative treatment such as intra-articular steroid or hyaluronic acid injections was permitted in order to minimize any possible confounding effect. If a subject was already taking glucosamine and chondroitin, the therapy was continued in the same dosage throughout the study period.

The testing was conducted before and after one year of a custom valgus knee brace therapy (Unloader® One, Össur Americas, CA) for the more symptomatic knee. Retro-reflective markers were anchored on bony prominences on the pelvis, thighs, legs, and feet. The subjects were asked to walk, in the braced and unbraced conditions, on a walkway instrumented with force plates (AMTI, MA and Bertec, OH). Three-dimensional kinematic gait data were captured at 120 Hz using a 12-camera motion capture system (Motion Analysis Corp., CA). Subjective assessment of knee pain and function was done using a visual-analog scale (VAS) and the Knee Osteoarthritis Outcome Score (KOOS), while the objective measurements included radiographic (knee joint space and tibio-femoral angle), kinematic (peak knee angles in three planes) and kinetic (peak knee moments in three planes) measurements. The knee joint space was measured on PA radiographs in 30° flexion and the tibio-femoral angle, by decreasing contact between the degenerated foci in the knee joint.

RESULTS
The VAS knee pain (Figure 1a) for stair ascent/descent was significantly reduced following one year of valgus bracing (64.3% on average, p = 0.032), while that for slow walking was reduced by 77.3% (p = 0.017). The VAS pain for fast walking was reduced by 59.3% but this was not statistically significant (p = 0.089). Based on average KOOS subscale values (Figure 1b), knee pain was reduced by 25.2% (p = 0.027), difficulty during activities of daily living (ADLs) by 18.3% (p = 0.295), difficulty during sports and recreational activities by 35.2% (p = 0.280). The overall quality of life was improved by 42.9% (p = 0.03). Note that greater KOOS values for all the subscales including pain indicate better knee function. Walking speed (p = 0.037) was greater at one year visit as compared to baseline. Stride length was also larger than that at baseline, although not significantly (p = 0.050). No significant differences were observed in the radiographic (Figure 1c and d) kinematic (Figure 1e) and kinetic (Figure 1f) variables between the baseline and one year follow up visits.

At baseline visit, only the radiographic tibio-femoral angle correlated with VAS pain during stair ascent/descent (p = 0.008). In contrast, the peak external rotation moment correlated with VAS pain during stair ascent/descent at one year follow-up visit (p = 0.015). None of the other variables significantly correlated with knee pain.

DISCUSSION
We observed significant functional improvement with valgus (unloading) brace therapy for varus knee OA, which concurs with previous studies. Valgus braces are designed to unload the medial knee compartment. Although the effectiveness of the unloading braces has been established, it is not known which objective measurements are altered, and how exactly the functional improvement and the reduction in joint pain are achieved.

We observed significant correlation of the radiographic tibio-femoral angle and the peak external rotation moment with knee pain during the baseline and one year visits respectively. In contrast to previous literature, we did not observe significant correlation between the peak adductor moment with knee pain.

Knee mechanics are known to be altered in varus knee OA, and the varus deformity is thought to have a rotational component. Significant correlation between the knee external rotation moment with knee pain may reflect this phenomenon. It is possible that the brace limits knee extension and alters rotations during gait, which may reduce joint pain by decreasing contact between the degenerated foci in the knee joint. Furthermore, the changes in knee rotations could have implications on kinematic coupling and the screw-home mechanism of the knee. We acknowledge that our limited sample size precludes any conclusions; however, these results may provide additional insights into alterations of knee mechanics in medial compartment OA and with valgus bracing.

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