Lower Extremity EMG during Stair Ascent Following TKA with Four Different Surgical Approaches

INTRODUCTION
The ability to climb stairs is an important part of independent living. Climbing stairs requires larger loads on the knee joint and increased range of motion compared to walking on a level surface (Costigan et al. 2002; Rowe et al. 2000). Knee OA patients experience pain, stiffness and decreased range of motion at the knee (Kaufman et al. 2001) making it difficult to navigate stairs. Previous research shows that individuals with knee OA climb stairs at a slower pace and with different lower limb kinematics, kinetics and muscle activation patterns. Following total knee arthroplasty (TKA), approximately fifty percent of patients report improved ability to use stairs (Moffet et al. 2004). The purpose of this study was to quantify differences in muscle activation patterns during stair climbing following TKA using four different minimally invasive surgical approaches.

METHODS
Fifty-eight test subjects aged 60 and older participated in this study at three time points: two, four and six months post-operatively. Each subject received one of four randomized surgical approaches: standard parapatellar (SP, n=15), miniparapatellar (MP, n=16), midvastus (MV, n=11) or subvastus (SV, n=16). Thirty-two healthy, age-matched control subjects were also evaluated at one time point. During motion capture of four successive ascending steps, a ten channel surface EMG system (MA-300-10, Motion Lab Systems, Baton Rouge, LA) was used. Surface EMG electrodes were affixed bilaterally to the skin overlying the rectus femoris, vastus medialis, and the hamstrings. The correct electrode placement was verified using manual muscle tests. Gains were calibrated prior to data collection using Motion Lab System Dataq monitoring and acquisition software. EMG data were recorded using EVaRT S during stair climbing trials.

Data were sampled at 1200 Hz and conditioned using MA-411-003 skin surface preamplifiers with 20x gain factor to record muscle potentials for each muscle during each trial. Raw EMG signals were plotted using LabVIEW to identify and omit any outliers or trials with a high signal to noise ratio. Raw EMG signals that were included after visual inspection were rectified then filtered using a double recursive 2nd order low pass filter with 50 Hz cutoff frequency. The signals were then normalized to the movement cycle as determined in OrthoTrak 6.2.8 and the hamstrings. The correct electrode placement was verified using manual muscle tests. Gains were calibrated prior to data collection using Motion Lab System Dataq monitoring and acquisition software. EMG data were recorded using EVaRT S during stair climbing trials.

DISCUSSION
Based on the results of this study the vastus medialis and hamstring activations of the sound limb, not the surgical limb, are most affected by total knee replacement surgery. This increased muscle activity could be due to compensation for deficiencies in the affected limb. Although the vastus medialis of the sound side is affected in some of the surgical groups, the midvastus surgical approach did not cause significant changes in the total firing time of the vastus medialis muscle on the affected side. This is consistent with the findings of Dalury, et al. (2008). Similar to the results of several previous clinical studies, the results of this study are not conclusive in determining whether any one surgical approach is more or less successful at restoring normal muscle firing patterns (Lonner 2006). The subvastus approach did not have significantly increased contraction time in any muscle tested in either limb. Of all the approaches, SV was the only one to not show compensatory firing in the sound limb. In conclusion, muscle activation patterns did vary based on surgical approach; however, this study does not show definitive support or opposition for any particular surgical approach. Future studies examining the differences in muscle activation following total knee replacement surgery should pay particular attention to the individual muscles of the knee flexor and extensor muscle groups.

REFERENCES