The Effect of Torsion Deformity and Medial Knee Osteoarthritis on Lower Limb Extensor Moments during Gait.

1David Mandeville, 2Sridhar Rachala, 1Rodney T. Imamura, 2Mary Bayers-Thering, 2Ken Krackow

1California State University, Sacramento, CA, USA
2Kaleida/Buffalo General Hospital Buffalo, NY, USA
email: dmandeville@csus.edu

INTRODUCTION

Hicks et al. (2007) found across a range of simulated excessive tibial torsion a diminished capacity of gluteus maximus, gluteus medius and the soleus to extend the hip and the knee during the single limb stance of gait. This result was interpreted to be due to altered geometry of bones about the vertical axis and the accompanying deviation of the muscles origins and insertions. The authors studied tibial torsion with respect to the crouched gait of cerebral palsy gait, however, tibial torsion deformity has also been reported for medial knee osteoarthritis (OA) subjects.

Krackow et al., (2011) showed that medial knee OA patients with tibial torsion deformity walked with greater knee varus moments than patients with medial knee OA and healthy controls. However, a kinetic characterization of the effect of tibial torsion on extensor muscle function during gait for knee OA subjects is needed. The total support moment (Ms), defined by (Winter, 1980) as the summation of the net joint moments at the hip, knee, and ankle joints, represents the magnitude of the extensor synergy of the lower extremity during stance phase of gait. This value has been isolated during the first peak vGRF to describe lower limb extensor moment function during the loading response phase of single limb stance for subjects with medial knee OA (Mandeville, 2007).

However, the effects of medial knee OA and tibial torsion on the extensor moments of the lower limb during single limb stance have not been reported. Therefore, the aim of this study was to quantify the effect of torsion deformity on the total moment of support, the hip, knee and ankle moments for patients with medial knee OA and torsion deformity, medial knee OA patients and healthy controls.

METHODS

Twenty-four subjects were recruited into 3 groups: end-staged medial KOA with torsion deformity (TKO, n = 6, BMI = 34.2 ± 3 kg/m², age = 61.8 ± 8 yrs.) and without torsion deformity (KOA, n = 8, BMI = 33.8 ± 7 kg/m², age = 59 ± 11 yrs.) and controls (CON, n = 10, BMI = 28.4 ± 4 kg/m², age = 62.5 ± 4 yrs.). Apparent torsion deformity was identified using a long standing lower extremity (LSLE) radiograph. The LSLE was used to classify knee OA disease severity for all subjects based on the Kellgren/Lawrence (K/L) scale; knee OA scores were ≥ 3 and controls were < 2.

The mechanical axis alignment for each study limb was measured by two evaluators (KAK and SRR) using the LSLE. Femoral and tibial torsion was assessed by two evaluators (SRR and DSM) using thin slice computed tomography (CT). A partially loaded-limb CT protocol was used to replicate the tibiofemoral joint angle (10° flexion) during the stance phase of gait. Patients were fitted into a torso harness attached to a foot base plate which was loaded with an axial compression force of approximately 55 N. The feet were secured to the base plate in the toe-out angle determined from an ink and paper gait test. Digital LSLE and CT images were archived and measured using a PC workstation.

Sagittal internal net joint moments were determined using level walking motion analysis involving two force plates and eight-cameras. A Newton/Euler inverse dynamic analysis was used to calculate the internal hip, knee, and ankle joint moments. These net joint moments (normalized to % body weight *
body height) were extracted at the first peak vertical ground reaction force and summed to present the total moment of support (MS).

Analysis of co-variance using gait velocity as a covariate was used to test for between-group differences for the moment of support, the hip, knee, and ankle joint moments, $\alpha < .05$.

RESULTS AND DISCUSSION

TKO showed a greater moment of support and a greater knee joint moment when compared to both KOA and CON.

These findings represent the kinetic synergy of the involved limb during weight acceptance. When controlling for gait velocity, the adjusted TKO values show a trend of increased extensor output at the hip, knee and ankle joints. Increased extensor output from TKO may be the result of an increased muscular response due to the altered skeletal geometry of the inwardly rotated tibia. Additionally, the increased extensor output may be a result of a stiff knee gait. At the first peak vGRF, knee flexion values were not significantly different between groups, but TKO accepted the body weight with a trend of less knee flexion (10.69 ± 13.29) than KOA (16.13 ± 6.98) and CON (14.83 ± 4.29).

CONCLUSIONS

Transverse plane deformity of the tibia in combination with the fixed sagittal plane orientation of the knee may increase the extensor demands during weight acceptance for knee OA patients with torsion deformity.