

CORRELATION BETWEEN KNEE ADDUCTION MOMENT AND THE RATIO OF MEDIAL-TO-LATERAL COMPARTMENT COMPRESSION IN SUBJECTS WITH KNEE OSTEOARTHRITIS UNDERGOING HIGH-TIBIAL OSTEOTOMY.

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INTRODUCTION

Patients with knee osteoarthritis (OA) have been shown to experience a larger external knee adduction moment during walking (Andriacchi and Mundermann, 2006). Therefore, an elevated peak knee adduction moment is considered a risk factor for medial compartment OA development and progression (Andriacchi, 1994). Knee adduction moment is also considered a good proxy measure for the magnitude of medial compartment compression (Miyazaki 2002). However, the correlation between these two quantities has not yet been established.

High-tibial osteotomy (HTO) is a common surgical procedure used to correct excessive varus knee alignment. A goal of HTO is to shift compressive loading from the medial to lateral compartment. However, this shifting of load has yet to be quantified in this patient group.

This study developed a numerical model of the internal structures of the knee joint, and used non-linear optimization to calculate the internal loading during walking gait. Of particular interest was the ratio of compression between the medial and lateral compartments. There were two goals of this study. First, determine the correlation between peak external knee adduction moment (KAM) and the ratio of medial-to-lateral compartment compressive loading ratio (MLR) both pre-HTO and post-HTO. Second, to quantify the shift of compressive load from medial to lateral compartments with HTO.

METHODS

30 patients (6 females, 24 males; mean age=50.0 ± 9.4 yrs.; BMI = 30.0±2.8) with clinically diagnosed OA primarily affecting the medial compartment of the knee underwent a medial opening wedge HTO. Walking gait analysis was performed immediately pre-surgery, and at six months post-surgery using optical motion analysis (8 Eagle cameras EvaRT system, Motion Analysis Corp, Santa Rosa, CA, USA) and floor-mounted force plate (OR6, AMTI, Watertown, MA, USA). The external joint kinetics were calculated using inverse dynamics.

The kinematic and forceplate data from the gait analysis also served as input for the internal knee joint model. The anatomical geometry was generic but scaled to patient height and knee alignment. Knee alignment was determined statically with standing full leg x-rays by the surgeon. Structures included in the model were four ligaments (ACL, PCL, LCL, MCL), two compressive contact surfaces (medial and lateral compartments) and 11 muscles (quadriceps, hamstrings, gracilis, sartorius, popliteus and gastrocnemius). Each loading surface was divided into 64 equal-area facets. A loading solution was found to satisfy mechanical equilibrium and minimize the sum of squares of all structural loads. Model output was the ratio of medial-to-lateral compartment compression (MLR).

Paired t-tests compared KAM pre-HTO versus post-HTO, and for peak MLR pre-HTO versus post-HTO. A Pearson R

coefficient was calculated correlating peak KAM to MLR for the all pooled subjects and for both pre-HTO and post-HTO conditions.

RESULTS AND DISCUSSION

The peak KAM decreased from 2.53 ± 1.32 [%BW*ht] pre-HTO to 1.63 ± 0.81 [%BW*ht] post-HTO ($p < 0.001$). The peak MLR decreased from 2.81 ± 0.62 to 1.69 ± 0.61 [dimensionless] ($p < 0.001$). The MLR is shown for a representative patient in Figure 1 during stance phase of gait for pre-HTO, 6-months post-HTO and 12-months post-HTO. A strong correlation was demonstrated between KAM and MLR for the pre-HTO and 6-month post-HTO conditions with the Pearson coefficients $r = 0.739$ and $r = 0.821$ respectively.

SUMMARY/CONCLUSIONS

These results suggest that adduction moment is a good proxy for quantifying the internal compressive loading in the knee. Even without considering muscle loading and possible co-contraction of antagonists, adduction moment explains nearly three-quarters of the variance in the internal loading. However, further research is required to increase confidence in this proxy measure in a clinical setting.

REFERENCES

- Andriacchi, T.P., Mundermann, A. (2006). *Curr Op Rheum*, 18: 514-8
Andriacchi, T.P. (1994). *Orthop Clin North Am* 25: 395-403
Miyazaki, T., et al. (2002). *Ann Rheum Dis*. 61: 617-22

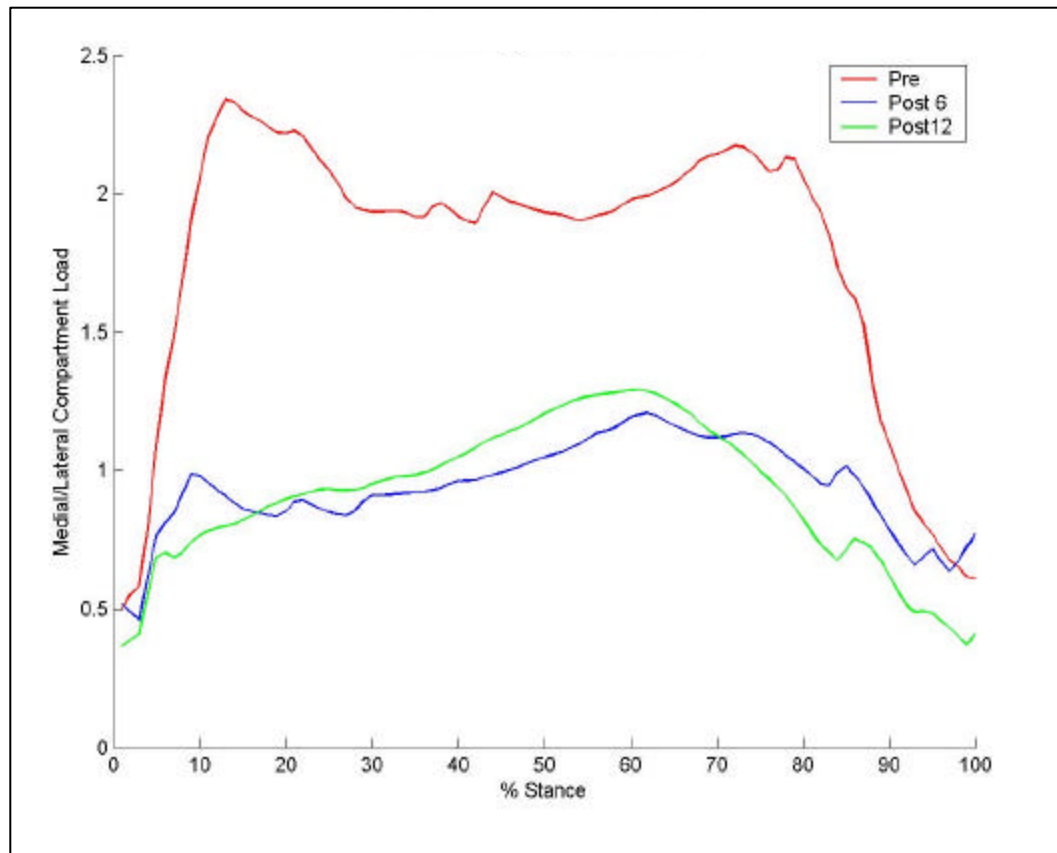


Figure 1: Medial-to-lateral compartment compression ratio (MLR) for a representative knee OA patient. Curves are shown for immediately pre-HTO surgery (Pre: red), 6-months post-HTO (Post6: blue) and 12-months post-HTO (Post12: green). The horizontal is normalized to 100% stance phase.