

The biomechanical characteristics features of varus thrust in patients with medial knee osteoarthritis -Quantified by three dimensional gait analysis-

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INTRODUCTION: Varus thrust is a biomechanical characteristic of severe medial knee osteoarthritis (OA) and is thought to be associated with OA progression. Previous studies reported that varus thrust excursion (varus movement with greatest magnitude within the first 30% of stance) [1] and peak knee varus angular velocity were higher in OA patients with varus thrust than without varus thrust [2]. However, sagittal and axial kinematics during varus thrust remains unclear. The purpose of this study was to clarify the characteristics of three dimensional knee kinematics of varus thrust in the medial OA patients.

METHODS: This study was conducted with a prior approval from the institutional ethical review board. One-hundred ninety-six patients who underwent three-dimensional gait analysis before total knee arthroplasty between 2017 to 2020 were enrolled in this study. Gait was examined for a varus thrust presence using video analysis (Figure 1) by five physical therapists with over 10 years of experience. Examiners judged whether varus thrust was present or not and the level of confidence in the assessment, using a 4 point Likert scale (0 - 4). Patient was classified as thrust (VT(+)) group when total score was 20 points and as non-thrust (VT(-)) group when total score was 0 points. Finally, 39 patients (20 patients in thrust group and 19 patients in non-thrust group) were included in this study. The Kellgren-Lawlence grade of knee osteoarthritis of all patients was grade 4. There were significant differences in age, the degree of knee flexion, leg alignment, joint line convergence angle between both groups. All patients were assessed while walking at a self-selected speed using an optical motion capture system; subsequently, six degrees of freedom knee joint kinematics were calculated using the Point Cluster Technique. The segment angle of femur and the tibia was measured in the global coordinate system, and calculated as the projected angle on each axis perpendicular to the global coordinate system. The medial-lateral displacement of the knee joint center was calculated as the change in the perpendicular distance from the knee joint center to the functional axis of lower limb along the X-axis. Statistical analysis was performed using student's t-test. P-values less than 0.05 were considered statistically significant.

RESULTS: Varus thrust was detected from initial foot contact to $13.4 \pm 2.3\%$ (range 9 to 19%) of the gait cycle. The difference in % gait cycle between contralateral heel off and the end of the varus thrust was $0.2 \pm 3.1\%$. Varus excursion during varus thrust (0 to 19% of gait cycle) was significantly higher in VT(+) group ($4.4 \pm 2.2^\circ$) than in VT(-) group ($1.6 \pm 1.2^\circ$) ($p < 0.01$). Flexion excursion was significantly lower in VT(+) group ($5.1 \pm 3.8^\circ$) than in VT(-) group ($10.3 \pm 3.5^\circ$) ($p < 0.01$). Knee flexion peak of gait cycle was significantly earlier ($10.8 \pm 1.8\%$) than in VT(-) group ($p < 0.01$) (Figure 2). There was no significant difference in rotation and anteroposterior excursion between both groups. The change in varus/valgus angle between the femur and tibia segments was significantly greater in the VT(+) group compared to the VT(-) group ($5.2 \pm 1.6^\circ$ vs $3.0 \pm 1.9^\circ$, $p = 0.01$). Both groups exhibited external rotation during the loading response phase, but there was no significant difference in the amount of change. The knee joint center significantly shifted outward during the loading response phase in the VT(+) group ($12.7 \pm 4.2\text{mm}$ vs $5.9 \pm 3.5\text{mm}$, $p < 0.01$). The external rotation velocity of the femur and tibia was not significantly different between the two groups during the early loading response phase (gait cycle 0-6%), but in the late loading response phase (gait cycle 7-12%), the external rotation velocity in VT(+) group was significantly faster than that in VT(-) group ($p < 0.01$) (Figure 3).

DISCUSSION: The result of video analysis of visual varus thrust that varus thrust almost corresponded to loading response phase of gait cycle. Higher varus excursion in thrust group was similar to previous studies [3-5]. This study also revealed the lower flexion excursion in thrust group. Computer modelling and simulation study reported that quadriceps was the most resistance to knee adduction moment in normal walking [6]. The weakened quadriceps muscle, therefore, could be a cause of the lower flexion excursion and varus thrust movement. The analysis of the segment in the global coordinate system revealed that dynamic knee varus motion in loading response phase and rapid external rotation motion in the late loading response phase were the characteristic features of varus thrust. These characteristics may be contributing factors for the exacerbation of knee OA caused by varus thrust.

SIGNIFICANCE:

REFERENCES: [1] Chang et al. Osteoarthritis cartilage 2003. [2] Kuroyanagi et al. Knee 2012. [3] Chang et al. Osteoarthritis cartilage 2003. [4] Fukaya et al. Knee 2015. [5] Mahmoudian et al. Clin Biomech 2016. [6] Shelburne et al. J Orthop Res 2006

IMAGES AND TABLES



Figure 1

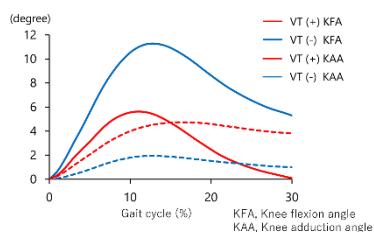


Figure 2

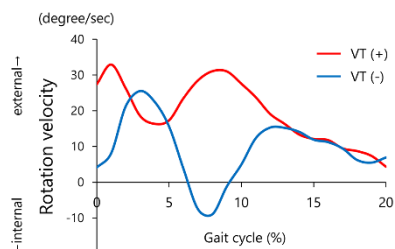


Figure 3