INTRODUCTION:
Knee osteoarthritis (OA) is a degenerative disease. Biomechanical studies have revealed a characteristic knee motion, particularly in severe cases. Most previous studies examined alterations in the frontal plane motion of the knee (knee abduction/adduction). We examined changes in knee kinematics and knee horizontal plane motion (tibial external/internal rotation) in knee OA patients. Our results show that tibial rotation angle differed between the knee OA patients and normal subjects during gait. The walking speed of most of the severe knee OA patients was limited, but whether the walking speed influences knee rotation remains unclear.

We aimed to investigate whether alteration in gait speed influences knee kinematics, particularly knee rotation, and to examine whether the degree of this alteration in patients with severe knee OA would differ from that in normal subjects.

METHODS:
Twenty-two patients with knee OA (mean age, 65.8 (6.5) years; range, 52–77 years) performed self-selected walking and fast walking on a 10-m walkway. Fast walking was performed at the fastest possible speed without experiencing pain. Subjects with a history of serious musculoskeletal injury, musculoskeletal injury in the past 6 months, and injury influencing gait were excluded. All subjects provided written informed consent; the study was performed in accordance to the guidelines approved by the Ethics Committee of Waseda University.

Three-dimensional lower limb movements were recorded using an 8-camera high-speed motion analysis system (Hawk; Motion Analysis Corp., Santa Rosa, CA). To determine foot contact patterns, ground reaction forces were recorded using a force plate (9287A; Kistler Japan Co. Ltd., Tokyo, Japan). The motion and force data were recorded at 200 Hz and 2000 Hz, respectively.

Twenty-five reflective markers were secured to the target lower limb (the painful or relatively painful limb). A two-segment model, including thigh and shank of the lower extremity, was created using Point Cluster Technique (PCT)\(^1\). Knee kinematics was calculated using the joint-coordinate system proposed by Grood and Suntay\(^2\). For PCT, the skin markers were classified into 2 groups: a cluster of points representing a segment and points representing bony landmarks. For the cluster of points, 10 and 6 markers were attached to the thigh and shank segment, respectively. The subjects were required to perform at least 5 successful trials of each type of walking.

In each trial, we calculated the angular displacements in flexion/extension, abduction/adduction, and external/internal tibial rotation by using PCT during the stance phase of gait. Each variable during foot contact and the peak value and angular excursion during 50% and 30% stance phase, respectively, were calculated. All independent variables were calculated for each trial and then averaged across the 5 trials.

Two-way ANOVA (severity × speed) was used to test the interaction between severity (early OA vs. severe OA) and walking speed (self-selected vs. fast speed). OA severity was graded using the Kellgren-Lawrence scale: grades 1 and 2 indicate early OA (n = 7), and grades 3 and 4, severe OA (n = 14). If the main effect was significant, then the differences among subjects with different grades of OA were analyzed using paired t-tests (a = 0.05 was considered significant).

RESULTS:
Figures 1, 2, and 3 show knee-joint movements in terms of OA severity and walking speed: knee flexion/extension (Fig.1), knee abduction/adduction (Fig.2), and external/interal tibial rotation (Fig.3).

Discussion:
The primary purpose of this study was to clarify the influence of OA severity and walking speed on knee kinematics, particularly tibial rotation.

In severe OA patients, obvious lateral knee motion during the stance phase can be seen on video images. In this study, the peak value of knee abduction was greater in severe OA patients than in early OA patients. Furthermore, the results concerning the knee abduction/adduction time course support this phenomenon.

The peak value of tibial internal rotation was lower in severe OA than in early OA patients. A previous study showed that severe OA patients exhibited external rotation deformity of the tibia\(^3\), which would limit tibial rotation in these patients. The peak value and angular excursion of tibial rotation were greater in subjects who performed fast walking than in those who performed self-selected walking. However, the knee abduction/adduction peak value was not influenced by the walking speed. This difference was unclear of this study. However, according to our data (not show), the changes in abduction/adduction differed from changes in tibial rotation with OA progression in subjects who performed self-selected walking. This difference might have influenced our results.

REFERENCES:
(1) Andriacchi TP et al; J Biomech Eng 120: 743-9, 1998
(3) Matsui Y et al; Cli Orthop Relat Res 433: 147-51, 2005