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Three-dimensional knee kinematics in patients with a discoid lateral meniscus during gait

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ABSTRACT

Background: To date, the knee kinematics of a discoid lateral meniscus (DLM) has not been elucidated. The aim was to investigate the three-dimensional knee kinematics in knees with a DLM using gait analysis.
Methods: Ten patients (mean: 14 years) diagnosed with bilateral DLM and unilaterally symptomatic snapping as well as 10 healthy controls (mean: 23 years) participated in the study. Each patient with a DLM had unilaterally snapping knee in full extension and deep flexion. The three-dimensional gait analysis was performed with the point cluster technique. All subjects were asked to walk on a level floor at the speed of their choice. In the sagittal plane, knee excursion was separately evaluated during the weight acceptance phase and the mid-stance phase. In the axial plane, knee excursion during the stance phase was assessed. Finally, knee excursion during the whole gait cycle was evaluated in the frontal plane. Statistical comparison was conducted between groups, and between both sides in the DLM group.
Results: In the sagittal plane, knee excursions during the weight acceptance phase and the mid-stance phase were significantly smaller in the DLM group than in the control group; in addition, these were smaller on the symptomatic side than on the asymptomatic side in the DLM group. In the axial plane, knee excursion was also significantly smaller on the symptomatic side than on the asymptomatic side in the DLM group, whereas the frontal knee motion did not differ significantly.
Conclusion: Less knee motion in the sagittal plane may prevent snapping during extension and flexion in patients with a DLM.
Level of Evidence: III.

1. Introduction

A discoid lateral meniscus (DLM) was first described in cadaver specimens in 1889. A DLM is an anatomic variant of the meniscus that is thickened and discoid-shaped. It covers a greater area of the tibial plateau than the normal meniscus does. Although a DLM is known to be a rare pathologic condition, a patient with a discoid meniscus will frequently present with symptoms due to the meniscal injury. It is more prevalent among Asians than in Caucasians. The actual incidence of discoid menisci is difficult to estimate due to the large numbers of asymptomatic patients. In Caucasian populations, the incidence varies between 0.4% and 5% [1–4]. Conversely, higher incidence rates have been reported in Indians (5.8%) [5], Koreans (9.1–10.5%) [6], and the Japanese (16.6%) [7]. Moreover, subjects with unilaterally symptomatic DLM often present with bilateral DLM [8].

A previous study indicated that meniscal excursion during flexion and extension will increase due to insufficient meniscal attachment to the tibia [3]. In 56% of patients, snapping occurs as a subjective symptom [9]. In 1948, Smillie et al. first described the cause of a snapping knee; they reported that the actual sound would be produced by the backward or forward movement of the meniscus when the femoral condyle rides over [10].

It is well known that the menisci act as load distributors and shock absorbers, and play an important role in knee joint stability. A meniscus-deficient knee carries a high risk of early cartilage degeneration and early degenerative changes [11,12]. Total meniscectomy of the DLM was associated with the development of degenerative changes of the knee in the long term [13]. Ultimately, patients with a DLM are at a greater risk of sustaining meniscal injuries. However, the actual cause of meniscal injury and the best treatment option (partial resection or repair) for such patients have not yet been determined. Thus, further

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Fig. 1. The three-dimensional gait analysis was carried out by using the point cluster technique, in which used 23 reflective markers were placed on each segment of the lower limb and iliac crest, as described by Andriacchi. The two calibration markers (medial femoral epicondyle and medial malleolus) were removed after the standing trial, and the other 21 markers remained on the subject throughout the data collection session.

insight into the knee kinematics in patients with DLM is needed. Although many studies have included patients with a ligament-deficient knee [14–18], the dynamic knee function in patients with meniscal injury using gait analysis has not yet been evaluated. Moreover, studies on the knee kinematics during gait in patients with a DLM are scarce.

Previous gait analyses in patients with a ligament-deficient knee reveal an abnormal gait pattern in the sagittal plane. It was hypothesized that the gait mechanics in the sagittal plane shows an abnormal pattern in patients with a DLM to prevent snapping. The aim of the current study was to investigate and elucidate the three-dimensional knee kinematics in such patients using gait analysis.

2. Materials and methods

2.1. Subjects

Ten patients (seven female and three male) aged 11–18 years of age (mean 14 years) who were diagnosed with bilateral DLM by magnetic resonance imaging were included in the study. The average body mass index (BMI) ± was 20.0 ± 1.8 kg/m^2. Each patient with a DLM had a unilaterally snapping knee in full extension and deep flexion. The onset of symptoms in each patient was insidious without any specific traumatic cause. On physical examination, each patient was found to have a full range of motion.

In addition, 10 healthy controls (three female and seven male), aged 22–26 (mean 23) years, also participated in the current study. The average BMI ± was 20.3 ± 2.1 kg/m^2. They had no history of any serious lower limb injuries, including posterior cruciate injury, medial or lateral collateral ligament injury, and symptomatic radiographic evidence of osteoarthritis. All subjects provided informed consent, and the study was approved by our institution.

2.2. Gait analysis

Gait analysis was conducted at a gait laboratory before arthroscopic surgery. The measurements were performed using a ten-camera system (120 frames/s; Vicon MX, Oxford Metrics, Oxford, UK). The three-dimensional gait analysis was conducted using the point cluster technique as described by Andriacchi et al. [19] (.1). Retroreflective markers were placed on standardized landmarks, as described by the biomechanical model of Andriacchi et al. [19] A set of markers were placed on the following anatomical locations of the measured limb: the iliac crest, the greater trochanter, medial and lateral femoral epicondyles, medial and lateral malleoli, the head of the fifth metatarsal bone, and the lateral side of the calcaneus. Further, additional tracking markers were placed on the frontal and lateral aspects of the thigh (nine markers) and the shank (six markers). Two calibration markers (medial femoral epicondyle and medial malleolus) were removed

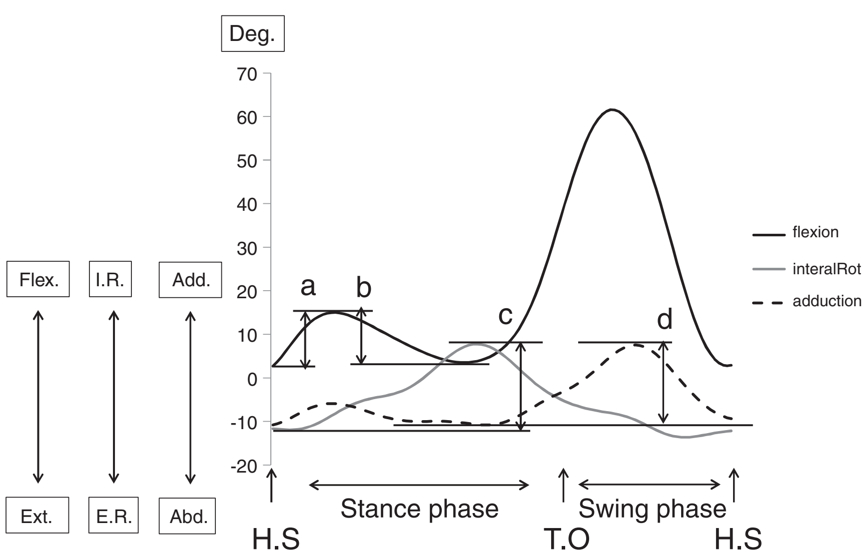

Fig. 2. Knee excursion was evaluated during the weight acceptance phase (a) and the mid-stance phase (b) in the sagittal plane. Specifically, the first peak minus the initial value was defined as Angle a, and the first peak minus mid-stance minimum was defined as Angle b. In the axial plane, knee excursion during the stance phase was assessed (c). In the frontal plane, knee excursion during whole the entire gait cycle was evaluated (d). (H.S.: heel strike, T.O.: toe off, Flex.: flexion, Ext.: extension, I.R.: internal rotation, E.R.: external rotation, Add.: adduction, Abd.: abduction).