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Daily cumulative hip moment is associated with radiographic progression of secondary hip osteoarthritis

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SUMMARY

Objective: To investigate whether higher daily cumulative hip moment at baseline is associated with subsequent radiographic progression of hip osteoarthritis (OA) over 12 months.
Design: Fifty patients with secondary hip OA, excluding patients with end-stage hip OA, participated in this prospective cohort study. Joint space width (JSW) of the hip was measured at baseline and 12 months later. With radiographic progression of hip OA (>0.5 mm/year in JSW) as dependent variable (yes/no), univariable and multivariable logistic regression analyses were performed to assess the association between load-related parameters during gait (i.e., peak hip moment, hip moment impulse, and daily cumulative hip moment [product of hip moment impulse and mean steps/day]) and hip OA progression with and without adjustment for age, body weight, and minimum JSW.
Results: Of the 50 patients (47.4 ± 10.7 years old), 21 (42.0%) were classified into the progression group. The higher daily cumulative hip moment in the frontal plane at baseline was statistically significantly associated with radiographic progression of hip OA (adjusted odds ratio (OR) [95% confidence interval (CI)], 1.34 [1.06–1.70]; $P = 0.013$). The higher daily cumulative hip moment in the sagittal plane was also approaching significance in its association with hip OA progression (adjusted OR, 1.80 [0.99–3.26]; $P = 0.052$).
Conclusions: In the female patients with secondary hip OA, higher daily cumulative hip moment, particularly in the frontal plane, was a predictor of radiographic progression of hip OA over 12 months. Reduction in daily cumulative hip moment by modification in gait and physical activity may potentially slow hip OA progression.

Introduction

Although progression of hip osteoarthritis (OA) seems to be multifactorial, genetic mutation[1], higher age[2], female, narrower joint space width (JSW) and higher Kellgren and Lawrence score at baseline[2,3], abnormal hip morphology such as hip dysplasia[1,2,4,5], atrophic bone response[2,6], and hip pain[3] are known potential risk factors for progression of hip OA. Especially for secondary hip OA, which is more prevalent than primary OA[7], abnormal hip morphology and malalignment between acetabular and proximal femoral head play an important role in radiographic progression[4,8].

In knee OA, a mechanical factor (i.e., excessive knee adduction moment and moment impulse during gait) has been identified as an important contributor to OA progression[9–13]. However, gait biomechanics associated with progression of hip OA remain unknown. Extended exposure to heavy physical work such as heavy lifting and standing can increase the risk for hip OA[14], although it is not known whether excessive load during gait is related to progression of hip OA. A recent longitudinal study reported that patients with hip OA who later underwent total hip arthroplasty (THA) had less hip extension moment and hip extension angle during gait at baseline compared to those without surgery[15]. Although that study did not necessarily examine the causal relationship between gait and radiographic progression since the decision of operation depends on multiple factors, it highlights the need for investigation of the association between gait biomechanics and progression of hip OA. However, the mechanical risk factor during gait for hip OA progression has not been identified.

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The external joint moment during gait can be used to estimate mechanical load since joint load cannot be directly measured *in vivo* noninvasively. Hip contact force during gait can be predicted from absolute hip joint moment in the three planes during the stance phase of gait[16,17]. Peak joint moment and joint moment impulse have been used as indicators of joint load[11,13]. Peak joint moment represents instantaneous load at a specific point during stance phase, and moment impulse measures the total amount of load during stance phase by incorporating both load magnitude and duration. Furthermore, total exposure to joint load during daily activities has been measured as daily cumulative joint moment calculated as the product of the moment impulse during the stance phase and the mean number of steps/day[18]. Daily cumulative moment may be particularly important, as it was nearly doubled in the patients with knee OA compared with the healthy individuals[19], and daily cumulative hip moment was associated with JSW in patients with hip OA in cross-sectional studies[20].

The purpose of this study was to evaluate the association between mechanical load during gait at baseline and subsequent radiographic progression of hip OA over 12 months. Given that cartilage degeneration depends on load magnitude and duration[21,22], it is possible that mechanical load during gait, especially daily cumulative hip moment rather than the peak moment and moment impulse, could critically influence degeneration of hip joint. We hypothesized that daily cumulative hip moment at baseline is associated with radiographic progression of hip OA.

Patients and methods

Patients

In this prospective cohort study, non-surgical outpatients were selected in the Department of Orthopaedic Surgery at Kyoto University Hospital. Patients with secondary hip OA aged 20 years and older were recruited from April 2013 to March 2015. A total of 53 patients were eligible for inclusion in our study, and were measured at baseline. Three patients were excluded from analysis because of missing measurements 12 months later.

The inclusion criteria were as follows: (1) a diagnosis of pre-osteoarthritis (acetabular dysplasia with no other abnormal radiographic findings) or early (slight joint space narrowing and abnormal subchondral sclerosis) or advanced-stage (marked joint space narrowing with or without cysts or sclerosis) hip OA, and (2) ability to walk without any assistive device in daily life. The exclusion criteria were as follows: (1) patients with a baseline JSW of <0.5 mm, as more than 0.5 mm/year in JSW was defined as progression of hip OA; (2) a history of previous hip surgeries (e.g., osteotomy, arthroplasty); and (3) neurologic, vascular, or other conditions that affect gait or activity of daily living.

Although the candidates for our study included both males and females, our sample was biased in gender (percentage of males: 7.1%), similar to previous reports on secondary hip OA (percentage of males: 7.6–9.2%)[8,23,24]. Therefore, only female patients were included in this study. Many of the patients had bilateral hip OA, and the side on which the radiographic OA change was more severe was used for analysis. All participants provided informed consent, and the protocol was approved by the Ethics Committee of the Kyoto University Graduate School and Faculty of Medicine (protocol identification number: E1683).

Radiographic assessment

A digital supine anteroposterior pelvic radiograph was obtained in a standardized manner by the same skilled radiology technicians at baseline and approximately 12 months later. The influence of position (supine vs standing) on the radiographic parameters of hip joint is discrepant[25–27]. However, radiographic parameters regarding hip dysplasia and JSW differ little between supine and standing anteroposterior radiographs[25,27]. Therefore, to improve image quality, we used radiograph in the supine position. Radiography at baseline was performed within 30 days prior to gait analysis. To avoid unnecessary radiation exposure, we used radiographs taken for general practice. From the radiograph, a single experienced examiner measured JSW to assess degeneration, Sharp angle, lateral center edge (CE) angle, acetabular head index (AHI), and acetabular roof obliquity (ARO) to assess morphologic abnormalities. These measurements had high inter- and intra-rater reliability[28,29], and are commonly used to diagnose dysplasia and hip OA[29]. Images were reviewed and measured on Centricity Enterprise Web, version 3.0 (GE Health care, Buckinghamshire, England). The JSW was measured at three locations, lateral margin of the subchondral sclerotic line, apical transection of the weight-bearing surface by a vertical line through the center of femoral head, and medial margin of the weight-bearing surface bordering on the fovea, in 0.1 mm increments from an image magnified four times (Fig. 1). If the minimum JSW was found aside from the three locations in the weight-bearing area, JSW of the narrowest point was also recorded as a fourth measurement. According to previous research[4], minimum JSW was defined as the smallest of these three or four measurements. The intrarater reliability [intraclass correlation (ICC) 1,1] of each radiographic measurement for 20 randomly selected radiographs was 0.95–0.99.

To assess the change in JSW, films at baseline and approximately 12 months later were paired by patients but blinded as to patient and sequence to the reader to avoid bias, as recommended[29]. All radiographic measurements were performed by the same examiner. Radiographic progression of hip OA has been defined as a reduction of more than 0.5 mm in JSW based on minimum detectable change (MDC) of the JSW[30,31]. Although the MDC_{95} (MDC at 95% confidence level) of the JSW in the current study was 0.39 mm by using the formula (MDC_{95} = standard error of

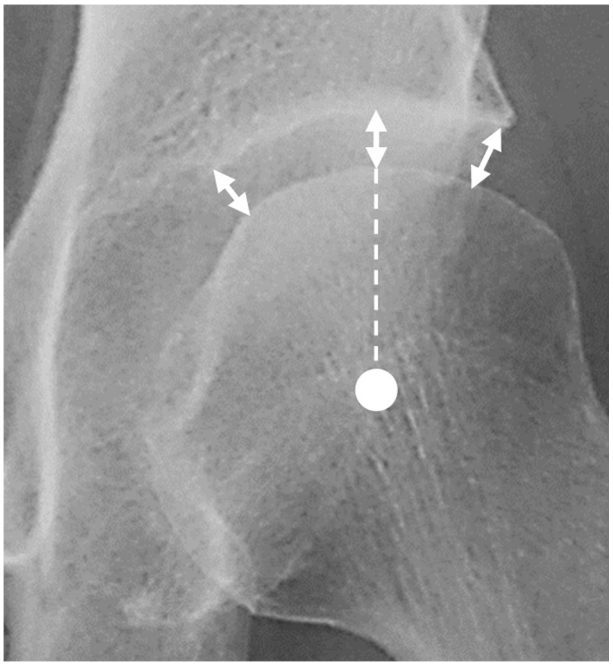

Fig. 1. The three measurement locations of the JSW of the hip joint. If the minimum JSW was found aside from the three locations, it was recorded as a fourth measurement.