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Radiographic and clinical factors associated with one-leg standing and gait in patients with mild-to-moderate secondary hip osteoarthritis

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ABSTRACT

A decline in physical function associated with secondary hip osteoarthritis (OA) may be caused by both radiographic and clinical factors; however, the underlying mechanism remains unclear. The purpose of this study was to determine how joint degeneration, hip morphology, pain, hip range of motion (ROM), and hip muscle strength relate to one-leg standing (OLS) and gait in patients with mild-to-moderate secondary hip osteoarthritis. Fifty-five female patients (ages 22–65 years) with mild-to-moderate hip OA secondary to hip dysplasia were consecutively enrolled. Balance during OLS and three-dimensional hip angle changes while maintaining the OLS and at foot-off of the raised leg were measured. Gait speed and peak three-dimensional hip joint angles during gait were also measured. The associations between dependent variables (balance, gait speed, and hip kinematic changes) and independent variables (age, body mass index, pain, joint degeneration, hip morphologic abnormality, passive hip ROM, and hip muscle strength) were determined. While lower hip muscle strength was associated with hip kinematic changes such as flexion and internal rotation while maintaining OLS, decreased acetabular head index (AHI) and increased pain were associated with hip extension and abduction at foot-off in OLS. Decreased passive hip ROM was associated with decreased peak hip angles (extension, adduction, and external and internal rotation) during gait, although increased pain and decreased hip extension muscle strength were associated with slower gait speed. In this study of patients with secondary hip OA, AHI, pain, and hip impairments were associated with OLS and gait independently from age and radiographic degeneration.

1. Introduction

Acetabular dysplasia resulting in reduced load-transfer areas is a significant risk factor for the incidence and progression of hip osteoarthritis (OA) [1]. Secondary hip OA is more prevalent than the primary form and typically has an early onset [2]. Young individuals are often exposed to high physical loads in their daily life [3]; secondary hip OA progresses joint degeneration and disabilities from a young age. Recently, treatment strategies for hip OA have shifted towards prevention during its early phases, including preosteoarthritis [4]. Investigation of declining physical function is important, particularly in young patients with mild-to-moderate hip OA.

Symptoms and hip impairments such as reduced range of motion (ROM) and muscle strength lead to compromised basic physical functions such as gait [5]. Maintaining balance and joint alignment during standing is also required during housework and standing work; physical work load during standing has been identified as a risk factor for hip OA [6]. Impaired balance and pelvic obliquity during one-leg standing (OLS), and decreased speed and hip joint excursion during gait have been reported in patients with hip OA [7–9]. On clinical examination, positive Trendelenburg's sign was found in 38% and limp was present in 85% of patients with acetabular dysplasia [7]. Therefore, exploring the cause of decline in basic physical function such as OLS and gait in patients with hip OA is a critical issue.

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A decline in physical function associated with OA progression may be caused by joint degeneration and morphologic abnormalities evident on radiographs and by clinical factors such as symptoms and impairments; however, the underlying mechanism remains unclear. Previous studies have reported relationship between hip extension muscle strength or hip flexion ROM and gait speed [10,11], and between pain or hip abduction muscle strength and hip moment or pelvic and trunk rotation during gait [12,13]. However, these previous studies have focused on end-stage hip OA or have included limited factors in their association analyses. To our knowledge, no other studies have comprehensively investigated the factors that influence OLS and gait in patients with hip OA patients before end-stage of disease.

Kinematic changes are directly linked to changes not only in kinetic parameters such as joint moment but also in load-transfer areas, and consequent changes in cartilage contact stress [14]; hence, kinematic observation as well as physical performance (i.e., balance during OLS and gait speed) are required for assessment of patients with hip OA. Knowledge of the associations between these variables and basic physical functions may assist clinicians in improving physical function in patients with hip OA. The aim of this study was to determine how various factors including age, joint degeneration, hip morphology, pain, hip ROM, and hip muscle strength relates to performance and hip kinematic changes during OLS and gait in patients with mild-to-moderate secondary hip OA.

2. Methods

2.1. Participants

Fifty-five patients with hip OA secondary to acetabular dysplasia diagnosed at the department of orthopedic surgery of university hospital from April 2013 to June 2015 participated in this study. The inclusion criterion was as follows: 20–65 years old, diagnosis of hip OA up to advanced stage (marked joint space narrowing), and the ability to walk without an assistive device and to maintain OLS for at least 10 s. OA severity was determined by the orthopedic surgeons based on the Japanese Orthopaedic Association classification of hip OA. Patients with history of previous hip surgeries, and neurologic or other conditions that affected OLS and gait were excluded. Our study included only female patients since the available study population was gender-biased (6.9% men), similar to previous studies [15]. Many of the patients had bilateral hip OA, the side with more severe radiographic OA change was analyzed. All participants provided informed consent, and our ethics committee approved the protocol.

2.2. Radiographic assessment

A single examiner measured minimum joint space width (mJSW) to assess joint degeneration, Sharp angle, lateral center edge (CE) angle, acetabular head index (AHI), and acetabular roof obliquity (ARO) to assess morphologic abnormalities using a standardized supine anteroposterior digital radiograph. The radiographs were obtained in a standardized manner by the same skilled radiology technicians, within 30 days prior to the clinical, OLS, and gait assessment. These measurements had high inter- and intrarater reliability [16,17], and are commonly used to diagnose dysplasia and OA [17]. Images were reviewed on Centricity Enterprise Web, version 3.0 (GE Health care, Buckinghamshire, England). The intrarater reliability [intraclass correlation (ICC) 1,1] of the measurement and standard error of the measurement (SEM) for 20 randomly selected radiographic assessments were 0.99, 0.14 (mJSW; ICC, SEM); 0.97, 1.02 (Sharp angle); 0.98, 1.23 (CE angle); 0.98, 1.36 (AHI); and 0.95,1.54 (ARO), respectively.

2.3. Pain assessment

The average hip pain intensity in the last 3 months was assessed on a 100-mm visual analog scale, where 0 was no pain and 100 was the worst imaginable pain.

2.4. Hip ROM test

A single examiner conducted passive ROM test. Passive hip ROM was measured using a standard two-arm goniometer (Sakai medical Co., Ltd, Tokyo, Japan) in accordance with previous studies [18].

Patient's position for each ROM test was as follows: hip flexion, supine with knee flexion; hip abduction, supine with the contralateral hip positioned in 10° abduction to stabilize the pelvis; hip adduction, supine with the contralateral hip positioned in slight flexion; hip external rotation and internal rotation, prone with 90° of knee flexion. The hip extension ROM was measured in the supine position with the hip joints positioned at the edge of the treatment table and the contralateral hip was flexed to flatten the lumbar spine and stabilize the pelvis. The angle between the ipsilateral femur and the horizontal line was measured with the ipsilateral hip and knee hanging freely [18]. A stabilization belt was applied across the pelvis and contralateral thigh during rotation and flexion ROM tests, respectively. The end of ROM was defined as the point at which the examiner felt a firm end feeling at which patient pain restricted further movement [18]. ROM was recorded to the nearest 1° and was measured once. The ICC (1,1) and SEM for the ROM tests were 0.98, 2.24 (flexion; ICC, SEM); 0.82, 1.46 (extension); 0.90, 1.99 (abduction); 0.89, 0.95 (adduction); 0.99, 0.98 (external rotation); and 0.99, 1.35 (internal rotation), respectively.

2.5. Hip muscle strength test

The maximal isometric muscle strength of hip flexion, extension, abduction, external rotation, and internal rotation were measured using a handheld dynamometer (μTAS F-1: Anima Co., Ltd, Tokyo, Japan) by one examiner, as previously reported [18,19].

Patient's position for each muscle test was as follows: hip flexion, sitting on a treatment table with 90° of hip and knee flexion; hip extension, supine with 20° of hip flexion and 0° of knee flexion; abduction, supine with both hips in a neutral position; hip rotations, prone with 90° of knee flexion. To stabilize the body and pelvis, patients were instructed to hold the edge of the treatment table, and a stabilization belt was applied across the pelvis or contralateral thigh during hip extension and rotation tests or abduction test, respectively. The sensor pad of the handheld dynamometer was placed 5 cm above the patella for flexion and abduction tests, and 5 cm above the malleolus for extension and rotations tests. For each strength test, all patients performed two maximal trials for 3 s after few practice trials. The mean of the two trials was used for analysis. Each strength value and lever arm was converted into a ratio of torque to body weight (Nm/kg). The ICC (1,1) and SEM for the muscle strength tests were 0.93, 13.03 (flexion; ICC, SEM); 0.96, 3.34 (extension); 0.93, 9.95 (abduction); 0.98,3.34 (external rotation); and 0.85, 9.03 (internal rotation), respectively.

2.6. Motion analysis

Body kinematics was recorded using Vicon motion system (Vicon Motion Systems Ltd., Oxford, England) at a sampling rate of 200 Hz and a fourth-order Butterworth low-pass filter with a 6 Hz cutoff, and with force plates (Kistler Japan Co., Ltd. Tokyo, Japan) at a sampling rate of 1000 Hz and a low-pass filter (20 Hz),