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Foot pressure pattern, hindfoot deformities, and their associations with foot pain in individuals with advanced medial knee osteoarthritis

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ABSTRACT

This survey clarified foot pressure patterns and hindfoot deformities in individuals with advanced knee osteoarthritis (OA) and analyzed their associations with foot pain. Sixty-four individuals with unilateral knee OA who underwent total knee arthroplasty (TKA) were divided into the following groups: no foot pain (n = 26; men:women, 4:22; mean age, 73.7 years), foot pain resolved after TKA (12; 2:10; 75.8), and foot pain remaining after TKA (26; 4:22; 74.7). Elderly individuals without pain or deformity in either knee (54; 10:44; 74.3) were controls. Navicular height ratio of the medial longitudinal arch, leg–heel angle, and partial foot pressure as the percentage of body weight (%PFP) were calculated.%PFPs of the medial and lateral heel regions before TKA were significantly lower for the no foot pain group than for controls. One year after TKA, %PFP improved significantly. In the foot pain resolved group, before TKA, the leg–heel angle was significantly higher, and%PFPs of the medial and lateral heel regions and navicular height ratio before TKA were significantly lower than those of controls. One year after TKA, all parameters improved significantly. In the foot pain remaining group, similar abnormalities were observed before TKA; however, significant improvement was only observed for%PFP of the medial heel region 1 year after TKA. More than half of the patients with advanced knee OA had foot pain. This improved in approximately one-third, 1 year after TKA. Hindfoot deformities are probably associated with foot pain in individuals with advanced knee OA.

1. Introduction

Knee osteoarthritis (OA) is a common joint disease in the elderly. Individuals with advanced knee OA usually have knee pain, limited range of motion (ROM), and functional limitations [1,2]. Total knee arthroplasty (TKA) significantly improves knee symptoms and is widely used to treat such cases. However, in clinical practice, many individuals have foot pain (FP) before TKA, and some still report FP after TKA despite knee pain improvement. FP may be a secondary or compensatory phenomenon adopted by individuals to lessen the load of the OA-affected knee [3]. Several foot deformities or disorders associated with knee OA have been reported, with flatfoot being the most common [4–6]. Arthritis of the ankle joint is another cause of knee OA-associated FP, and several individuals exhibited newly developed or progressive ankle arthritis after TKA [7]. Zhou et al. [8] recently suggested that insufficiency of the posterior tibial muscle is associated with FP in individuals with flatfoot and subtalar joint OA. However, the clinical course and frequency of FP associated with advanced knee OA remain unclear. This study investigated midfoot and hindfoot deformities in individuals with advanced knee OA and analyzed their relationships with FP.

2. Methods

2.1. Participants

Sixty-four individuals with unilateral knee OA treated at Ugo Municipal Hospital in Japan (10 men, 54 women; mean age, 74 years; range, 63–86 years) were enrolled. All individuals reported knee pain during gait and were admitted to the hospital for TKA. All examinations were performed on the day before and 1 year after TKA diagnosis. An experienced orthopedic surgeon blinded to the clinical data graded OA

Abbreviations: COP, center of pressure; %PFP, partial foot pressure as the percentage of body weight; %Long, anteroposterior length of the COP path as a percentage of foot length; %Trans, transverse width of the COP path as the percentage of foot width; OA, osteoarthritis; TKA, total knee arthroplasty; VAS, visual analogue scale; ROM, range of motion; FP, foot pain

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according to radiographs [9] using the Kellgren and Lawrence [10] scale. Individuals with multiple thoracolumbar compression fractures, systemic inflammatory arthropathies, a history of knee surgery, and/or the inability to understand Japanese were excluded. Knee ROM and femorotibial angle on knee radiographs were examined for patients with advanced knee OA. The control group comprised 54 elderly individuals (10 men, 44 women; mean age, 74 years; range, 63–85 years) without any pain, deformity, or apparent OA changes around either knee. Lack of pain in both knees during gait was confirmed during the interview. The review board of the Akita University Graduate School of Health Science approved this study, and written informed consent for the collection and use of the information was obtained from all respondents in accordance with the Declaration of Helsinki.

2.2. Subgrouping of individuals with knee OA according to FP

FP locations before and 1 year after TKA for individuals with knee OA were recoded from medical charts and interviews. FP intensity was measured using a visual analogue scale (VAS) [11], and patients without FP were classified as the no FP group. Individuals with FP before TKA were further divided into those who had or did not have FP 1 year after TKA (FP remaining and FP resolved groups, respectively). The FP location was determined and classified as medial, lateral, or anterior. Radiographs were examined to confirm OA of the ankle and subtalar joint.

2.3. Foot pressure measurement

Foot pressure was measured on a flat 16-m walking course while walking at a comfortable speed. Flexible pressure-sensitive sheets of the foot pressure measurement system (F-Scan II[1]) were attached to the insoles of the trial shoes (Shin-Nipponkyouiku Shoes[2]). The F-Scan II comprises pressure-sensitive sheets linked to a computer, and the path of the center of pressure (COP), foot-printed area, and foot pressures of the foot were recorded automatically [12]. Participants walked on the course 3 times for measurements after 1 or 2 practice walks. Values of the 3 trials were averaged.

Walking speed was calculated using the distance of the middle part of the walkway (10 m) and the time spent walking on the middle part. Maximum foot width was calculated using the foot-printed area data, and maximum foot widths on both sides were calculated. The navicular height ratio of the medial longitudinal arch of the foot was calculated as the height of the tubercle of the navicular from the floor and expressed as the percentage of the foot length (Fig. 1, left) [13]. Foot length was measured using the data of the foot-printed area. The leg–heel angle was measured as the angle formed by lines of the center of the lower leg axis and center of the heel axis (Fig. 1, right) [14,15]. Supination and pronation angles were denoted as negative and positive values, respectively. Partial foot pressure was expressed as the percentage of body weight (%PFP) (Fig. 2). The foot-printed area during gait was divided into the medial heel, lateral heel, central, metatarsal, hallux, and lateral toes according to the average foot length of healthy Japanese individuals [16,17].%PFP was calculated as the average value during the stance phase of each step during each part as the percentage of the body weight. The anteroposterior length of the COP path was measured and expressed as the percentage of the foot length (%Long) [16]. The transverse width of the COP path was measured from the most medial to the most lateral point of the COP path and expressed as the percentage of the maximum foot width (%Trans). All lengths were measured using the software included with the F-Scan II.

[1] Manufacturer: F-Scan II, Nitta, 4-4-26 Sakuragawa, Naniwa, Osaka City, Osaka, Japan.

[2] Manufacturer: Shin-Nipponkyouiku shoes, 1-9-3 Kanryou, Otsu City, Shiga, Japan.

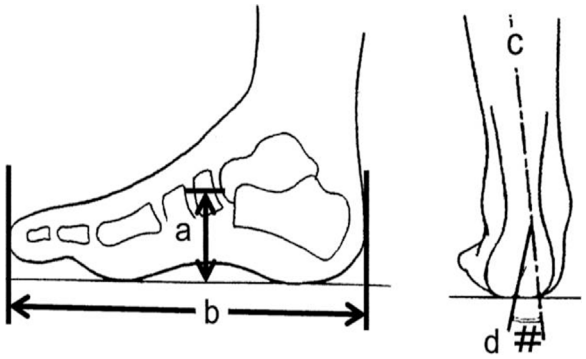

Fig. 1. Measurement of the height rate of the medial longitudinal arch (Left) and leg–heel angle (Right).
The height of the tubercle of the navicular from the floor (a) was measured and expressed as the percentage of foot length (b). Foot length was measured from the data of the foot-printed area. The leg–heel angle (#) was measured as the angle formed by lines of the center of the lower leg axis (c) and the center of the heel axis (d).

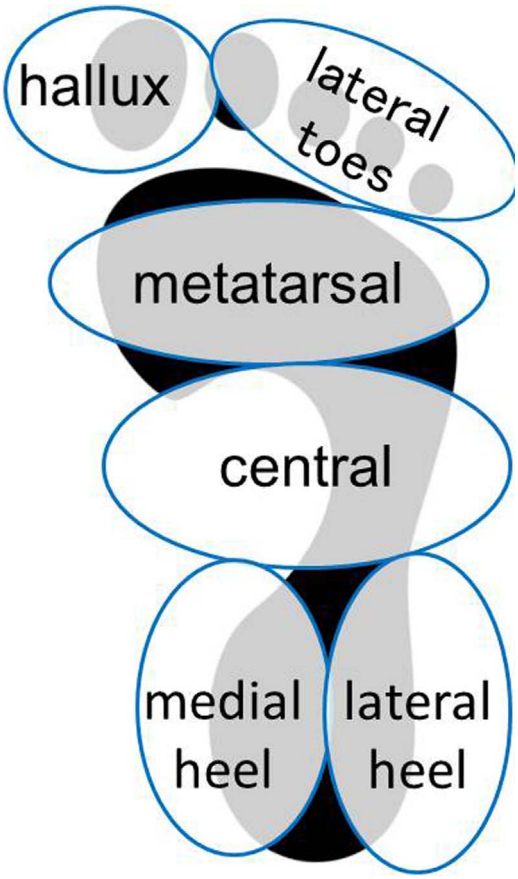

Fig. 2. Areas of partial foot pressure per body weight (%PFP) measurement.
The foot-printed area during walking was divided into the medial heel, lateral heel, central, metatarsal, hallux, and lateral toes.

2.4. Statistical analysis

Parameters before TKA were compared among groups using the Kruskal–Wallis test with a Bonferroni post hoc test. Changes in parameters before and after TKA were compared using paired *t*-tests. The distribution of FP location was analyzed with the χ^2 test. The relationship between the navicular height ratio and leg–heel angle was analyzed using Spearman's rank correlation coefficient. Significance was set at $p < 0.05$. All analyses were performed using SPSS 18.0.[3]