

A Positive Association Between Foot Posture Index and Medial Compartment Knee Osteoarthritis in Moroccan People

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Abstract: *Objectives:* To compare foot posture in people with and without medial compartment knee osteoarthritis (OA), and to assess association between its abnormalities and medial compartment knee OA.

Methods: We compared the foot posture of patients with clinically and radiographically-confirmed medial compartment knee OA and asymptomatic healthy controls using the foot posture index (FPI), navicular height, and the medial arch.

Results: We included 100 patients and 80 asymptomatic controls. The mean age of patients was 59 ± 7 (44-76) years and 48 ± 9 (28-60) years in the control ($p=0.06$). Patients group have more pronated foot for FPI (1.50 ± 2.68 vs 0.72 ± 2.63 ; $p=0.05$), more flat foot (42% vs 22%; $p=0.03$), and less pes cavus than the control group (58% vs 77%; $p=0.004$). However, there was no significant difference between the groups in the navicular height (3.90 ± 0.85 cm vs 4.00 ± 0.76 cm; $p=0.41$).

In multivariate statistical analysis, after adjusting for age and body mass index, pronated foot in FPI (OR=1.22, 95%IC= [1.06-1.40], $p=0.005$), and pes cavus (OR=0.32, 95%IC= [0.11-0.93], $p=0.03$) had a significant correlation with the knee osteoarthritis.

Conclusion: Pronated foot posture and flat foot are significantly associated with medial compartment knee osteoarthritis.

Keywords: Foot posture, foot posture index, knee osteoarthritis, medial arch, medial compartment, navicular height.

BACKGROUND

Foot posture might change the mechanical alignment, dynamic function and the development of musculoskeletal conditions of the lower limb. Foot orthoses, knee braces, and footwear are non operative treatment for osteoarthritis (OA) reducing the knee adduction moment and the loading on the medial compartment as well [1-9]. So, foot posture assessment is the first requirement to select the patients with medial knee osteoarthritis qualified for the non operative treatment. The foot posture measurements include the foot posture index (FPI) [10], navicular height and the medial arch index. The FPI is a valid clinical tool with a good inter-item reliability. It quantifies the degree to which a foot can be considered as being in a pronation, supination or neutral position. The evaluation of the medial arch is made by measuring the Djian-Annonier angle on the radiograph of the foot in side view. It is drawn from the lowest point of the calcaneus, the talar head and sesamoids. It is between 120 and 125 °, a lower value indicates a hollow foot (pes cavus) and a higher indicates a flat foot. The measurement of navicular height is a direct anthropometric measure of the distance between the navicular tuberosity and ground with the subject in relaxed calcaneal stance.

Although it is important to know and to understand the foot characteristics in patients with medial knee osteoarthritis, few studies have examined the foot posture in this population. Two interesting studies compared foot posture index (FPI) scores between people with knee OA and controls, and the conclusion assumed that people with medial compartment knee OA have a more pronated foot type in comparison with controls [11,12].

The aim of our study was to evaluate foot characteristics of medial compartment knee OA patients and asymptomatic people in Morocco, and to assess the degree of the association between foot posture and knee OA in comparison to other population.

PATIENTS AND METHODS

We designed a case-control study comparing the foot posture in patients with medial knee osteoarthritis with a control group of healthy people.

Patients

The patient group was defined as any patient who consults for knee pain related to medial knee osteoarthritis diagnosed on X-ray. In patients with bilateral knee OA we studied the most painful side. Each compartment of the knee joint (medial compartment, lateral compartment and patella-femoral compartment) was graded and participants with predominantly medial compartment OA were included in the

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study. Participants from the OA group were included if they were able to walk independently without any pre-existing neurological or other orthopaedic condition that affected their walking. Patients with a history of trauma of the knee, an inflammatory arthritis or microcrystalline pathology and previous joint injury were excluded from the study.

The control group consisted of healthy people with no clinical knee osteoarthritis selected from general population.

All patients and controls gave their written informed consent before being included in the study.

Methods

All measures were made by the same examiner. We noted the weight, height and BMI of the two groups. An examination of the knee was performed in the group of patients in search of a genu varus or valgus. The grade of the knee OA was assessed using the Kellgren and Lawrence classification on a radiograph of the knee. For both groups, we measured in the lower limb affected by osteoarthritis the navicular height, the foot posture index (FPI) and the medial arch. The latest approved version of the FPI consists of six items and each item is scored between -2 and + 2 [10]. The overall posture of the foot is the sum of the different measures, so a neutral foot corresponds to a score of 0, a pronated foot corresponds to a positive value and a negative value indicates a supination position. The various items of the foot posture index are the talar head palpation, the supra and infra lateral malleolar curvature, the calcaneal frontal plane position, the bulging in the region of the talonavicular joint, the height and congruence of the medial longitudinal arch and the abduction / adduction of the forefoot on the rear foot. All observations were made with subjects standing on both lower limbs. Assessment of the symptomatic leg (or the most symptomatic leg in a case of bilateral involvement) in OA group and the same leg of each peer control was done.

Statistical Analysis

A descriptive analysis was performed first; qualitative variables were presented as a proportion and continuous variables as a mean \pm SD and median.

An univariate analysis was then conducted using t test or non parametric test (Mann-Whitney) to compare means. The Chi2 statistics were used for comparison of proportions.

Backwards-manual selection in binary logistic regression model was used to estimate the association of knee OA with explanatory factors. Factors associated with p value < 20% in univariate analyses were included in the initial multivariate logistic model. The algorithm used to eliminate variables, for instance: First, factors were eliminated from the binomial logistic regression models based on their significance level. Secondly, main effects of potential confounders were selected for elimination if they did not influence the estimated OR and had a negative influence on the global model-fit. Adjusted odds ratios (ORa) and 95% confidence intervals (CI) are reported for each determinant.

Statistical analysis was carried out using the SPSS, v18. The level of significance was established for p value <0.05.

RESULTS

Demographic Characteristics

Two groups participated in the study: a knee OA group and an age-matched and gender-matched healthy control group. The OA group included one hundred patients whose X-ray was positive for the medial compartment OA. The control group included eighty participants. The demographic characteristics of both groups are summarized in Table 1. Height and body mass index were similar between the groups (p=0.94 and p= 0.45 respectively).

Table 1. Participant's demographic characteristics.

	Patients (n=100)	Control Group (n=80)	p Value
Age (years)*	59.68 \pm 7.64	48.66 \pm 9.30	0.06
Female n (%)	79 (79%)	60 (75%)	0.52
Weight (Kg)*	80.12 \pm 9.43	72.66 \pm 8.06	0.08
Height (cm)*	161.49 \pm 7.31	161.42 \pm 6.24	0.94
Body mass index (kg/m ²)*	30.89 \pm 4.94	28.00 \pm 3.81	0.45

* Values are reported as mean \pm SD.

Foot Posture Analysis

Statistical analysis showed significant differences between the two groups. Patients group have more pronated foot for FPI (1.50 \pm 2.68 vs 0.72 \pm 2.63; p=0.05), more flat foot (42% vs 22%; p=0.03), and less pes cavus than the control group (58% vs 77%; p=0.004). However, there was no significant differences between the groups in the navicular height (3.90 \pm 0.85 cm vs 4.00 \pm 0.76 cm; p=0.41).

In multivariate statistical analysis, after adjusting for age and body mass index, pronated foot in FPI (OR=1.22, 95%IC= [1.06-1.40], p=0.005), and pes cavus (OR=0.32, 95%IC= [0.11-0.93], p=0.03) had a significant correlation with the knee osteoarthritis (Table 2). Pronated foot was associated with medial knee osteoarthritis, while pes cavus was found to protect patient from knee OA.

Table 2. Multivariate statistical analysis results.

	Odds Ratio	Confident Interval (95%)	p Value
Foot posture index (Pronation position)	1.220	1.060 - 1.403	0.005
Medial arch index (pes cavus)	0.329	0.116 - 0.931	0.036

DISCUSSION

The results demonstrate an association between foot posture and medial knee osteoarthritis. Several recent studies have discussed the benefits of orthotics in decreasing the knees load, so it seems to be interesting to study the foot characteristics in patients with medial knee OA [13,14]. In this study, we investigated foot characteristics of people with medial compartment knee OA using three foot measures: the

FPI, navicular height and the medial arch index. Significant difference was found between the groups for foot measures. Our data suggest that pronated foot in FPI is associated with medial knee OA, while pes cavus seems to protect patients from medial knee OA. Flatfeet are susceptible to high degrees of pronation [15]. Our findings of positive association between medial knee OA and foot posture index are in agreement with several studies [11, 16]. Reilly *et al.* assessed the foot type of three groups of 60 people; the first one with medial compartment knee osteoarthritis, the second with hip osteoarthritis, and the third one with healthy age-matched controls [16]. This study showed significant difference between groups concerning ankle dorsiflexion and arches. They concluded that people with medial compartment knee OA had a normal ankle dorsiflexion and more pronated foot type as indicated by the FPI, while limited range of dorsiflexion and high arches were noted in the hip OA group, and significant difference was found between these two groups compared to controls [16]. However, we found no significant difference in navicular height between the groups, which is also in agreement with Reilly and colleagues. A study of U.S. Marine recruits found that flat or pronated feet were found to be associated with shin splints or knee pain [17]. It has been suggested that high-arched feet are inflexible [18], while flatfeet are more mobile and susceptible to high degrees of pronation [15,19]. Persisting subtalar pronation through midstance while the contralateral pelvic advancement is producing an external rotation on the femur contributes to placing the knee under high axial torsion [20]. During walking, which submits the knee to repetitive mechanical loads [21], most of the force is exerted through the medial compartment [22, 23]. Antero-medial OA of the knee has been proposed as a distinct clinical pathologic entity, the common localization of the lesions to the antero-medial quadrant of the joint suggests it is mechanically driven [22]. The antero-medial quadrant of the knee is the contact area when the leg is extended and fully weightbearing during the midstance phase of gait. This coincides with the timing of subtalar overpronation.

Abnormal foot posture was found in another study of people with severe knee medial compartment OA. In this study which compared the FPI scores between 20 people with knee OA and 20 controls, authors reported a significantly higher median score in those with knee OA, indicative of a more pronated foot posture [11]. Levinger and colleagues compared the FPI between 32 knee OA and 28 controls. They don't found any difference in navicular height between the two groups, however pronated foot type was noted in the knee OA group compared to controls [12]. Recently, Gross *et al.* reported an association between flat foot morphology and knee pain and medial tibio-femoral cartilage damage, which agrees with our findings [24].

It has been suggested that although the positions of the feet are not pathological, they can lead to a change in the attitude of the foot during walking either in internal or external rotation as the foot is respectively in pronation or supination [25-27]. Supination external rotation attitude can reduce the adduction moment taking action on the knee. The knee adduction moment estimate indirectly the internal stresses in the tibio-femoral compartment [28]. A change in the adduction moment indicates a modification of the

distribution of the knee joint load. The adduction moment depends on the mechanical alignment of the knee as well as on the reaction force on the floor [29]. The pronation attitude could move the center of pressure laterally and then decrease the adduction moment, so the foot could attempt to decrease the charge on medial compartment.

It is known that a neutral position without internal or external rotation in the relaxed foot attitude characterize the ideal foot posture. The goniometer used to measure the ankle motion is not adapted to assess pronation and supination. However, the measure using calcaneal angle and navicular height with a plumb line has good results and gives more precision about the alignment even though it is consuming more time and requires more competence [16]. The development of the foot posture index (FPI) by Redmond *et al.* in 2006 provided a clinical diagnosis tool. This index measures the position of the foot in all three planes of space and assesses two anatomical segments [10]. The FPI was explored in a population of healthy grown-up volunteers from 18 to 57 years old and proved its reliability and its abstract validity [13, 14]. The FPI gives a comprehensive description of foot posture. However, the FPI is not in wide use as well in osteoarthritic patients.

Whether pronated foot posture is a risk factor for, or a consequence of, medial compartment knee OA cannot be determined from cross-sectional studies such as ours. The question is whether the foot anomaly influences the site at which lower limb OA develops, or whether these changes are secondary to OA and should be considered as compensatory mechanisms. People with medial compartment knee OA often have genu varum malalignment of the knee, which has been shown to increase the risk of development and progression of knee OA. Genu varum malalignment of the knee may lead to compensatory foot pronation to enable the foot to be plantigrade when weightbearing [30]. None of our patients could affirm if the anomaly of its foot posture is acquired or if it is dated in childhood. Due to the potential effect of foot alignment on the loading axis of the lower limb, prospective studies are needed to better understand the contribution of foot structure and function to the development of internal femoro-tibial OA.

These findings could have therapeutic implications in the management of medial compartment knee OA, especially the use of the laterally wedged soles which can act on symptoms by reducing the knee adduction moment [31, 32]. However, laterally wedged insoles can alter foot motion, specifically increasing rearfoot pronation. Accentuation of rearfoot pronation in already pronated feet could potentially result in detrimental changes to lower limb kinematics [12]. But the addition of an arch support to laterally wedged insoles could maintain normal rearfoot motion while also enhancing the ability of the insole to reduce the knee adduction moment. A longitudinal investigation is required to better understand the contribution of orthotic and footwear interventions in the management of medial compartment knee OA.

CONCLUSION

The foot posture is strongly correlated with the internal femoro-tibial knee OA. In consequent, clinical examination of the feet in patients suffering from knee OA is primordial

by using the clinical tools such as FPI, which remains a simple tool of clinical diagnosis. The assessment of foot posture of people with medial compartment OA is necessary in order to improve our understanding of foot orthoses and foot wear modification on lower limbs alignment and function.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

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Received: July 7, 2013

Revised: October 14, 2014

Accepted: October 30, 2014

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