Gait & Posture 58 (2017) 394–400

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Full length article

Association of varus thrust with prevalent patellofemoral osteoarthritis: A cross-sectional study

Hirotaka Iijima[a,b,c,*], Naoto Fukutani[a], Yuko Yamamoto[d], Masakazu Hiraoka[e], Kazuyuki Miyanobu[d], Masashi Jinnouchi[f], Eishi Kaneda[d,e,f], Takuya Isho[a,g], Tomoki Aoyama[a], Hiroshi Kuroki[a], Shuichi Matsuda[h]

[a] Department of Physical Therapy, Human Health Sciences, Graduate School of Medicine, Kyoto University, Kyoto, Japan
[b] Japan Society for the Promotion of Science, Tokyo, Japan
[c] Department of System Design Engineering, Keio University, Yokohama, Japan
[d] Nozomi Orthopaedic Clinic, Hiroshima, Japan, Japan
[e] Nozomi Orthopaedic Clinic Studium, Hiroshima, Japan
[f] Nozomi Orthopaedic Clinic Hiroshima, Hiroshima, Japan
[g] Rehabilitation Center, Fujioka General Hospital, Gunma, Japan
[h] Department of Orthopaedic Surgery, Graduate School of Medicine, Kyoto University, Kyoto, Japan

ARTICLE INFO

Keywords:
Gait
Varus thrust
Patellofemoral osteoarthritis
Patellar alignment

ABSTRACT

This cross-sectional study investigated (i) the association of varus thrust during gait with the presence of patellofemoral osteoarthritis (PFOA) in patients with medial knee osteoarthritis (OA) and (ii) patellar alignment in the knees with varus thrust. Participants from orthopedic clinics (n = 171; mean age, 73.4 years; 71.9% female) diagnosed with radiographic medial knee OA (Kellgren/Lawrence [K/L] grade ≥1) were included in this study, and underwent gait observation for varus thrust assessment using 2D video analysis. A radiographic skyline view was used to assess the presence of medial PFOA using the grading system from the Osteoarthritis Research Society International Atlas. The tibiofemoral joint K/L grade, patellar alignment (i.e., lateral shift and tilting angle), and knee pain intensity were also evaluated as covariates. Thirty-two (18.7%) of 171 patients exhibited varus thrust and they presented significantly higher knee pain (46.0 ± 3.04 mm vs. 32.4 ± 2.73 mm; $P = 0.024$), a lower patellar tilting angle ($P = 0.024$), and a higher prevalence of PFOA compared with those without varus thrust. A logistic regression analysis with adjustment of covariates showed that varus thrust was significantly associated with higher odds of the presence of mixed and medial PFOA, and trended to significantly associate with any PFOA, including lateral PFOA. This indicates that varus thrust was associated with PFOA in a compartment-nonspecific manner in patients with medial knee OA. Varus thrust may represent a clinical disease feature of more advanced and multicompartmental disease.

1. Introduction

Osteoarthritis (OA) of the knee is a leading cause of chronic knee pain and disability [1]. Although knee OA is predominantly a disease affecting the tibiofemoral (TF) joint [2], the patellofemoral (PF) joint is also an important source of symptoms [3]. Epidemiologic and clinical studies involving the PF joint in isolation or in combination with the TF joint have increased recently [4,5]. Because patients with mixed OA exhibit severe clinical symptoms compared with those with isolated tibiofemoral osteoarthritis (TFOA) [6,7], further epidemiologic and clinical studies are warranted to understand the pathogenesis of mixed disease.

Although the factors contributing to the development of PFOA are still insufficiently characterized, biomechanical risk factors play a role [8]. One major factor is excessive frontal plane alignment of the TF joint. Radiographic studies show that varus-valgus alignment is associated with the prevalence and progression of PFOA in a compartment-specific manner [9,10]. Recently, a magnetic resonance imaging (MRI) study demonstrated that increases in valgus alignment were concurrently related to total patellar cartilage volume loss [11]. Although

* Corresponding author at: 53 Shogoin, Kawahara – cho, Sakyo – ku, Kyoto 606 – 8507, Japan.
E-mail addresses: iijima.hirotaka.4m@yt.sd.keio.ac.jp (H. Iijima), nafukutani@gmail.com (N. Fukutani), yukoyamamoto@nozomi-clinic.jp (Y. Yamamoto), masakazuhiraoka@nozomi-clinic.jp (M. Hiraoka), kazuyukimiyanobu@nozomi-clinic.jp (K. Miyanobu), jinnouchi@nozomi-clinic.jp (M. Jinnouchi), EishiKaneda@nozomi-clinic.jp (E. Kaneda), isho.tak@gmail.com (T. Isho), aoyama.tomoki.4e@kyoto-u.ac.jp (T. Aoyama), kuroki.hiroshi.6s@kyoto-u.ac.jp (H. Kuroki), smat522@kuhp.kyoto-u.ac.jp (S. Matsuda).

http://dx.doi.org/10.1016/j.gaitpost.2017.08.033
Received 11 November 2016; Received in revised form 17 August 2017; Accepted 27 August 2017

these findings may be explained by the biomechanical consequences based on the "law of valgus" (i.e., varus alignment increases the medial PF force and valgus alignment increases the lateral PF force) [12], these varus-valgus measurements are static measurements and may not replicate the PF-joint motion during weight-bearing activities [13,14]. Perhaps, dynamic measurement of frontal plane motion would be more valuable [8]. Considering that a recent large-scale study raised questions about the law of valgus owing to the high prevalence of medial PFOA in valgus knee [15], an improved understanding of the relationship of frontal plane malalignment with PF joint disease is warranted.

Varus thrust is an easily assessed measure of frontal plane dynamic motion of the knee, and The Varus thrust is defined as the dynamic worsening or abrupt onset of varus alignment as the limb accepts weight (stance phase), with a return to a less varus alignment during lift-off and the non-weight-bearing (swing phase) of gait [16,17]. Currently, varus thrust increases the odds of medial TFOA progression by four-fold [18] and is associated with knee pain in patients with knee OA [19,20]. Considering that static varus alignment is associated with the medial PFOA progression [10], and that patellar alignment is an important contributor to the PFOA progression in a compartment-specific and dose-response manner [21,22], varus thrust is expected to be associated with medial PFOA possibly *via* alteration of PF joint loading distribution. However, no study has examined the association of varus thrust with medial PFOA and patellar alignment relative to the trochlea in knees with varus thrust. This point of view is particularly important because varus thrust during gait is a mechanical factor that can be managed through non-surgical intervention [23]. Thus, varus thrust might be a new candidate as a modifiable biomechanical factor associated with PFOA if there is a significant biomechanical connection between varus thrust and medial PFOA.

This cross-sectional study was conducted to examine (i) the association of varus thrust during gait with PFOA presentation in patients with medial knee OA and (ii) patellar alignment in knees with varus thrust. The general hypothesis was (i) varus thrust is associated with the presence of PFOA in a compartment-specific manner (i.e., associated with the medial PFOA, but not the lateral PFOA) and (ii) knees with varus thrust have an altered patellar alignment compared with those without varus thrust, with the relationship of varus thrust with the medial PFOA being archived through altered patellar alignment. This knowledge would clarify the relationship between dynamic frontal plane instability and PF joint disease and could provide some basis to establish the pathogenesis of concurrent PF joint disease in patients with knee OA.

2. Methods

2.1. Participants

This study was approved by the ethical committee of our institution (approval number: E1923). Written informed consent was obtained from all participants before enrollment. The evidence level of this cross-sectional study is III. Data obtained from January 2014 to January 2015 was used.

Patients were recruited from the community orthopedics clinic. All recruited patients had a history of pain in one or both knees. All patients met the following inclusion criteria: (i) age ≥ 50 years; (ii) radiographic OA primarily in the medial TF compartment (Kellgren/Lawrence [K/L] grade [24] ≥1) of one or both knees, as evaluated using weight-bearing anteroposterior radiographs of the TF joint; and (iii) ability to walk independently on a flat surface without any ambulatory assistive devise. As pre-radiographically defined knee OA, particularly K/L grade 1, predicts radiographic OA progression to at least grade 2 within 3–5 years [25,26], we included patients with K/L grades ≥1. Patients with bilateral knee OA were not considered separately from unilateral cases. The exclusion criteria were: (i) a history of knee surgery, (ii) inflammatory arthritis, (iii) periarticular fracture, (iv) current neurological problems, or (v) lateral compartment knee OA. Lateral knee OA was defined as a knee having a K/L grade ≥1 along with joint space narrowing (JSN) > 0 in the lateral compartment with JSN = 0 in the medial compartment [27]. In other words, only patients who had a more severe radiographic disease in the medial compartment compared to the lateral compartment (i.e., isolated medial TFOA or mixed medial and lateral TFOA) were included in this study. Since medial and lateral knee OA have distinct characteristics [28], and most knee OA is the medial type in Japan [29,30], lateral knee OA (i.e., lateral OA severity > medial OA severity) was excluded in this study.

2.2. Measurements

Participants were tested using knee radiography (anteroposterior and skyline views) and gait observation for varus thrust. Knee radiography was used to assess OA severity, knee alignment, and PFOA presentation. Baseline characteristics and knee pain intensity quantified by visual analog scale (VAS) were also collected as covariates. All measurements were performed after enrollment.

2.2.1. Radiographic evaluation of the TF joint OA severity, presence of PFOA, and patellar alignment

A weight-bearing anteroposterior short film and a skyline view was obtained for each patient's knee. The skyline view was obtained while the patients were in the supine position, with the knee flexed to 45°. The radiographic severity of the TF joint was assessed in the anteroposterior view by experienced examiners (TA and HI), using the K/L grading system. The interrater agreements for the K/L grade determination were excellent (κ = 0.84, 95% confidence interval [CI] = 0.79–0.90).

The skyline PF images were assessed for joint space narrowing (JSN) and osteophytes according to the standard atlas from the Osteoarthritis Research Society International [27] by a single trained examiner (HI). Radiographic OA of the PF joints was diagnosed if any of the following criteria were fulfilled: (i) JSN ≥grade 2, (ii) the sum of the two marginal osteophyte grades from the same compartment ≥2, or (iii) grade 1 JSN combined with a grade 1 osteophyte in the same compartment. This cutoff is equivalent to grade 2 OA based on the K/L grading system [24]. Representative skyline views from knees *with* varus thrust and knees *without* definite varus thrust were shown in Fig. 1A. The lateral and medial compartments of the PF joint were each graded separately in skyline views; then, PFOA was classified as either isolated medial, isolated lateral, or mixed PFOA according to the location of the lesion in the PF joint. The intrarater reliabilities were excellent for JSN (medial: κ = 0.86, 95% CI = 0.79–0.93; lateral: κ = 0.85, 95% CI = 0.79–0.91), patella osteophyte grade (medial: κ = 0.92, 95% CI = 0.87–0.97; lateral: κ = 0.83, 95% CI = 0.76–0.89]), and trochlea osteophyte grade (medial: κ = 0.92, 95% CI = 0.87–0.97; lateral: κ = 0.92, 95% CI = 0.87–0.97) of the PF joint.

Patellar alignments were evaluated from the skyline view (Fig. 1B, C) by a single trained examiner (HI). Details regarding the measurement for the patellar alignments were recently described [6]. The intrarater reliabilities were excellent for the lateral displacement (intraclass correlation coefficient [ICC] = 0.91, 95% CI = 0.89–0.93) and tilting angle of the patella (ICC = 0.96, 95% CI = 0.95–0.97).

2.2.2. Gait observation for varus thrust

Participants underwent gait observation for varus thrust assessment (see Supplementary materials), shown in Fig. 2. Two experienced physical therapists classified varus thrust in patients' knees as being definitely present, possibly present, or definitely absent [19]. These patients were further categorized into two groups: "with definite varus thrust" (including patients with only varus thrust being definitely present) and "without definite varus thrust" (including those with varus thrust being possibly present and those with varus thrust being