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Muscle activation features of the osteoarthritic knee with patellar lateral subluxation

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KEYWORDS

Osteoarthritic knee
Patellar lateral subluxation
Electromyography
Vastus medialis obliquus
Vastus lateralis

ABSTRACT

Objective: The aim of the study was to compare the muscle activation feature of vastus medialis obliquus (VMO) and vastus lateralis (VL) between the osteoarthritic knee patients with patellar lateral subluxation (Group 1B) and without patellar lateral subluxation (Group 1A).
*Methods***:** Isokinetic muscle strength of the knee extensor was evaluated using a CYBEX NORM dynamometer with angular velocities of 80, 120 and 240 degrees/second (°/sec) respectively, contraction activities of VMO and VL muscle were recorded with synchronized surface electromyography (sEMG). Age-matched healthy subjects were recruited and served as control group (Group 2). The VMO/VL ratio of EMG between Group 1A, Group 1B and Group 2 were compared.
Results: The peak torque in Group A was 40.7±12.9, in Group B was 39.6±12.9 and in Group C was 60.2±9.5 respectively at 80°/sec angular velocity ($p<0.01$). There were no significant difference between Group 1A and Group 1B in the three trial of tested velocities ($p>0.01$). The sEMG ratios of VMO/VL of Group 1B calculated at angular velocities of 80/sec was 0.769±0.15, 120°/sec was 0.818±0.22 and 240°/sec was 0.850±0.22, all those were lower than Group 1A and Group 2 ($p<0.01$).
Conclusion: Musculature imbalance of VMO and VL may explain the different muscle activation pattern in osteoarthritic knee patients with and without patellar lateral subluxation.

1. Introduction

Osteoarthritis of the knee is the most common type of arthritis and one of the leading causes of disability in the elderly [1]. Radiographic assessment of knee OA, which is based on localization of joint space narrowing or cartilaginous degeneration, can be classified into tibiofemoral (TF) OA and patellofemoral (PF) OA [2]. In clinics, some people with knee OA have either mixed TF/PF OA disease or isolated disease in the medial TF compartment. Patellar lateral subluxation (PLS) is commonly observed in mixed OA population with skyline view radiography [2-5]. PLS is a translational deviation of the patella relative to femoral trochlea and it is frequently accompanied with tilt. The clinical features in knee OA patients with PLS are similar to those of the patellofemoral pain syndrome (PFPS): with distinctive disability in stair climbing and descending, and sudden pain while arising from a chair. The combination of subluxation and tilt may lead to arthrosis because of abnormal loading of articular cartilage [6].

Knee OA is associated with a variety of pathophysiological conditions. Previous studies have shown that quadriceps weakness may be one of the important factors in the progression of knee OA [7-11]. In terms of biomechanical function, the quadriceps provides anteroposterior stability to the knee. It is able to absorb loads of impact transmitting through the TF joint and to protect the joint from stress during gait [8]. Quadriceps weakness may alter sites of mechanical loading of the joint surface, and that may result in damage to the articular cartilage [8-9]. During the knee extension phase, the patella acts as a balance pivot that transmits the quadriceps force to the patellar tendon and this improves the efficiency of the quadriceps by increasing the lever arm of the extensor mechanics [12]. The dynamic position of the patella is depended on the vectors of the quadriceps muscle group which are made up of the VMO and VL muscles [13]. In the terminal 30 degrees from flexion to extension, the “screw home” mechanism rotates the tibia outward relative to the femur; tension on the quadriceps will tend to produce a lateral displacement vector of the patella because of the laterally displaced tibial tuberosity and the increased Q angle. This lateral vector is resisted by the VMO, the medial retinaculum and the lateral facet of the trochlea. To the contrary, the tibia rotates inward during the first 30 degrees of flexion, decreasing the Q angle and the lateral vector, and the patella is drawn into the trochlea [13]. Thus, several studies have suggested that

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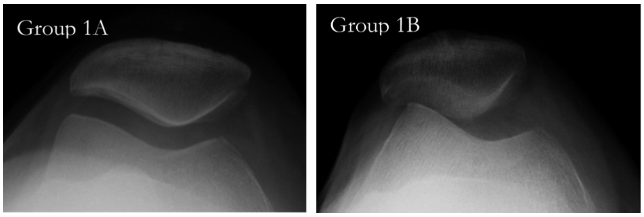

Fig. 1. Distinguishing between medial TF OA knee with and without PLS by Merchant's view radiography.

Table 1
Characteristics of the participants.

	Group 1A	Group 1B	Group 2	p value
Sex (M/F)	3/8	5/10	5/7	p>0.05
Age	61.1+10.3	63.2+10.6	61.6+6.7	p>0.05
Height (m)	156.0+9.8	161.0+7.1	157.8+8.3	p>0.05
Weight (kg)	59.7+9.3	64.5+10.6	58.1+10.2	p>0.05
BMI (kg/m^2)	24.4+2.4	24.8+4.2	23.2+2.1	p>0.05
Lequesne's Index	6.9+3.9	6.1+3.3		p>0.05

BMI: body mass index; M: male; F: female.

deficiency of the VMO or excessive pull of the VL on the patella may cause malalignment of the extensor mechanism as well as abnormal patellar tracking [14,15]. McAlindon et al. [2] thought that abnormality in the PF joint might play an important role of causing knee pain and disability in patients with knee OA.

It has generally been agreed that quadriceps weakness was related with knee OA in all compartments [7,8,11]. However, compared with isolated medial TF knee OA patients, it is unclear that whether patients with PLS have weaker knee extension strength or have muscle imbalance involving the VMO and VL. There are few reports in the literature documenting differences of extensor mechanism in biomechanics between knee OA patients with and without PLS.

Understanding the contraction patterns of the VMO and VL muscles may be an important step for the selection of rehabilitative treatment program for the knee OA patients with PLS. Surface EMG is a useful tool and is able to record the muscle activity of the various quadriceps muscle group [15-19]. The aims of this study were to evaluate the muscle strength and ratio of EMG activity, and try to comprehend the effect of the PLS on knee OA patients. The hypothesis proposed here was that different muscle activation feature might occur in knee OA patients with and without PLS during isokinetic concentric knee extension exercise.

2. Methods

2.1. Subjects

Twenty six subjects with bilateral knees OA were included in this study. The severity of their knees OA were diagnosed, by anteroposterior radiography, as stage I or II according to the grading of Kellgren/Lawrence [20]. Knee OA with or without PLS were diagnosed and classified by using Merchant's view which was obtained in the supine position with the subject's knee flexed at 45 degrees [21]. The knee OA patients were separated into two groups, there were eleven patients with TF OA alone in Group 1A and fifteen patients with TF OA combined with PLS in Group 1B (Figure 1). Twelve age-matched healthy subjects were recruited and served as control Group 2. We had measured the alignment of patellofemoral joint including the congruence angle, lateral patellofemoral angle and percentage of lateral patellar displacement (Figure 2). The congruence angle, which was used to measure the relationship between the patellar articular ridge and the groove of the femoral trochlear (Figure 2a), was defined by Merchant et al. [21]. The positive value or greater than 16 degrees is considered to be abnormal and indicates lateral instability of the patella [13]. Patellar tilting was diagnosed from the lateral PF angle (Figure 2b). Angles that are less than 7 degrees or negative may indicate an abnormal situation and a lateral tilt [22]. The method of measuring lateral patellar displacement was described by Keblish et al. [23] (Figure 2c). The ratio for normal tracking is near 100%.

All subjects signed informed consent before participating. Pain symptoms and activities of daily living of the patients with knee OA were assessed using the Lequesne's Index [24]. The characteristics of each group are presented in Table 1. These three groups were well matched for age, sex, body mass index (BMI) and Lequesne's index.

2.2. Procedure

Isokinetic assessment of the knee extensor muscles was evaluated by using a Cybex Norm dynamometer (Cybex International, Inc. USA) and the contraction activities of the VMO and VL muscles were recorded by EMG. Three angular velocities (80, 120 and 240 degrees/sec) were tested during knee extension in order to assess the effect of velocity on EMG ratio. Subjects were positioned on the Cybex dynamometer with their back supported and the hips flexed to 85 degrees as required by the user's manual. Trunk and thigh straps were fastened for stabilization. The testing began with a series of five repetitive isokinetic concentric contractions from 90° (flexion) to 0° (extension) at each speed. Each subject was encouraged to perform maximal contraction with visual feedback. Both legs of all subjects in the three groups were tested. The muscle torque was measured in foot-pounds (ft-lbs) and normalized against body weight (%BW).

BIOPAC MP100 (BIOPAC Systems, Inc., USA), a system with six channels and bipolar gold-plated surface electrodes, was

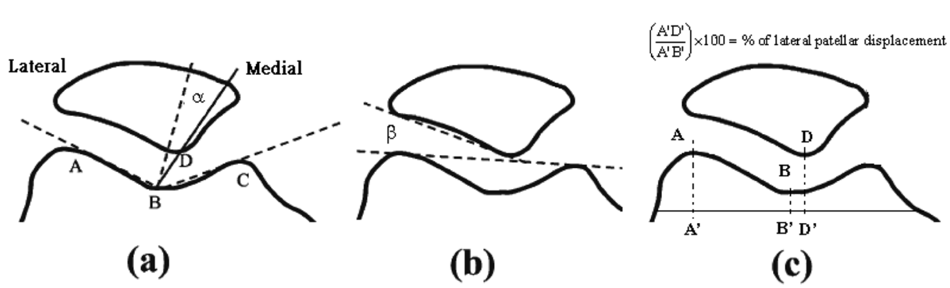

Fig. 2. Measurement of the PFJ anatomy. (a) Congruence angle (α). The congruence angle is measured between the bisector line of sulcus angle ($\angle$ABC) and a line joining the apex of the point B and the lowest point of the patellar articular surface D; (b) lateral PF angle (β)[32]; (c) perpendicular lines (AA', BB' and DD') were dropped to a horizontal line. Percentage of lateral patellar displacement (%) was defined by the ratio A'D'/A'B'.