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Hylonome

Case Report Article

The effects of a varus unloader brace for lateral tibiofemoral osteoarthritis and valgus malalignment after anterior cruciate ligament reconstruction: a single case study

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Abstract

We investigated the immediate effects of a varus knee brace on knee symptoms and knee-joint biomechanics in an individual with predominant lateral tibiofemoral joint osteoarthritis (TFJOA) and valgus malalignment after anterior cruciate ligament (ACL) reconstruction. A varus unloader brace was prescribed to a 48-year-old male with predominant lateral radiographic and symptomatic TFJOA and valgus malalignment eight-years following ACL reconstruction. During a step-down task, the participant rated knee pain, task-difficulty, knee-stability and knee-confidence on four separate visual analogue scales. Quantitative gait analysis was conducted during self-selected walking trials under three test conditions in a randomized order: (i) no brace; (ii) brace without frontal plane adjustment (no varus re-alignment); and (ii) brace with frontal plane adjustment (varus re-alignment). Post-processing of gait data involved calculation of knee kinematics and net joint moments for the reconstructed limb. The participant reported improved pain (3%), task difficulty (41%), stability (46%) and confidence (49%) when performing the step-down task with the brace. The varus brace resulted in immediate reductions in knee abduction angle (24%) and internal rotation angle (56%), and increased knee adduction moment (18%). These findings provide preliminary evidence for potentially beneficial effects of bracing on knee-symptoms and biomechanics in individuals with lateral TFJOA after reconstruction.

Keywords: Anterior Cruciate Ligament Reconstruction, Lateral Tibiofemoral Osteoarthritis, Valgus Malalignment, Varus Unloader Brace

Introduction

Post-traumatic knee osteoarthritis (OA) occurs in 50-70% of people in the 10-15 years following anterior cruciate ligament (ACL) reconstruction[1]. Notably, lateral tibiofemoral joint osteoarthritis (TFJOA) occurs more frequently after ACL reconstruction (~50%) than in elderly knee OA populations (~20%)[2,3]. Lateral TFJOA is associated with biomechanics that is distinct from medial TFJOA, including greater peak knee abduction angles and lower peak external knee abduction moments[4]. As a consequence, it is unlikely that interventions designed for people with predominant medial TFJOA will be appropriate for those with lateral TFJOA. Therefore, we believe it is important to investigate targeted interventions with the potential to address compartment-specific gait biomechanics in people with lateral TFJOA following ACL reconstruction.

Valgus bracing is frequently prescribed for medial TFJOA, with the intent to provide an external knee valgus force and thus offload the medial TFJ compartment. Such braces can reduce frontal plane malalignment[5], external knee adduction moments[5], and medial knee load during walking[6]. Valgus bracing has also been shown to improve pain and function in individuals with predominantly medial knee OA[5]. In contrast, varus bracing is designed to provide an external knee varus force and

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thus, reduce lateral compartment contact stresses. Thus, it is plausible that varus bracing could have beneficial effects for lateral TFJOA after ACL reconstruction; however no studies to date have evaluated these effects. This study investigated the effect of varus bracing on knee-related symptoms and knee joint biomechanics in an individual with lateral TFJOA and valgus malalignment after ACL reconstruction. We hypothesized that the varus brace would improve self-reported pain, knee-stability, and confidence, reduce task-difficulty and knee adduction angles; and increase external knee adduction moments.

Case history

A 48-year old male (height 1.83 m, weight 78 kg) was referred to a private physiotherapy clinic in Melbourne, Australia. He had undergone ACL reconstruction (hamstring-tendon autograft) eight years earlier. Activities such as walking, especially on uneven surfaces, were becoming increasingly difficult, occasionally requiring a walking stick due to knee instability. The participant completed the Knee Injury and Osteoarthritis Outcome Score (KOOS)[7] and reported severe limitations with sports and recreation function and reduced quality-of-life (KOOS-Pain=72; KOOS-Symptoms=64; KOOS-ADL=91; KOOS-Sports/Rec=0; and KOOS-QOL=6)[8]. Radiographic OA was most pronounced in the lateral TFJ compartment and associated with a valgus malalignment of 174°, measured as per published methods[9]. Despite regular physiotherapy, involving manual therapy, exercise prescription and application of therapeutic taping, non-steroidal anti-inflammatory drugs, hyaluran injections and arthroscopic debridement of his lateral TFJ compartment, improvements in his symptoms and function had plateaued. Although his functional impairments related to left knee OA were severe, he was considered too young to undergo total knee arthroplasty.

The varus unloader brace (DJO Global, Vista, USA) is designed to control sagittal and transverse plane rotations associated with ACL reconstruction, in addition to correcting frontal plane malalignment. The brace was prescribed and adjusted to provide varus alignment according to patient-reported comfort (i.e. comfortable pressure distribution across contacting surfaces) during walking. The University of Melbourne's Human Research Ethics Committee granted ethical approval, and the participant provided written informed consent prior to data collection.

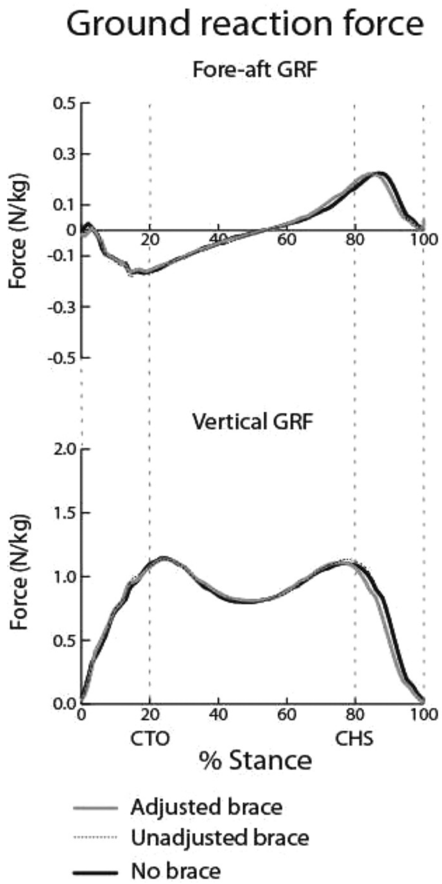

Figure 1. Ground reaction forces (GRF), fore-aft and vertical GRF, during the stance phase for the adjusted, unadjusted and no brace conditions. The dashed lines identify the ground reaction force at contralateral toe-off (CTO) and contralateral heel strike (CHS).

Methods

The immediate effects of knee bracing on knee-related symptoms were evaluated during a step-down test[10]. The test was performed with and without the varus brace and the participant rated his level of pain, task-difficulty, knee-stability and knee-related confidence on four separate 100 mm visual analogue scales (VAS), where 100 represented worst symptoms (higher difficulty/greater instability/lower confidence/greater pain) and zero represented no symptoms.

Quantitative gait analyses were performed at the Human Motion Laboratory, Department of Mechanical Engineering, University of Melbourne, to assess the effects of the brace, as per published methods[11]. To accommodate the brace, lateral and anterior thigh retro-reflective markers were attached proximally (above the upper frame of the brace) and anterior tibial markers were attached distally (below the strap). An initial static trial was used to calibrate relevant anatomic landmarks. The hip joint centre was defined as per Harrington et al.[12], while the orientation of the knee flexion-extension axis was determined using a dynamic optimization approach[13]. The participant performed trials of walking at a self-selected speed under three brace conditions: (i) no brace; (ii) brace without frontal plane adjustment; and (ii) brace with frontal plane adjustment (varus re-alignment). The unadjusted brace condition was used to assess the effects of sagittal plane support without frontal plane realignment. All trials for each brace condition were completed in the same block, with the order of brace conditions randomized via concealed allocation. A limited number of practice trials were provided for each testing condition. Post-processing of gait data involved the calculation of knee kinematics and net joint moments[14] for the ACL reconstructed limb. All data

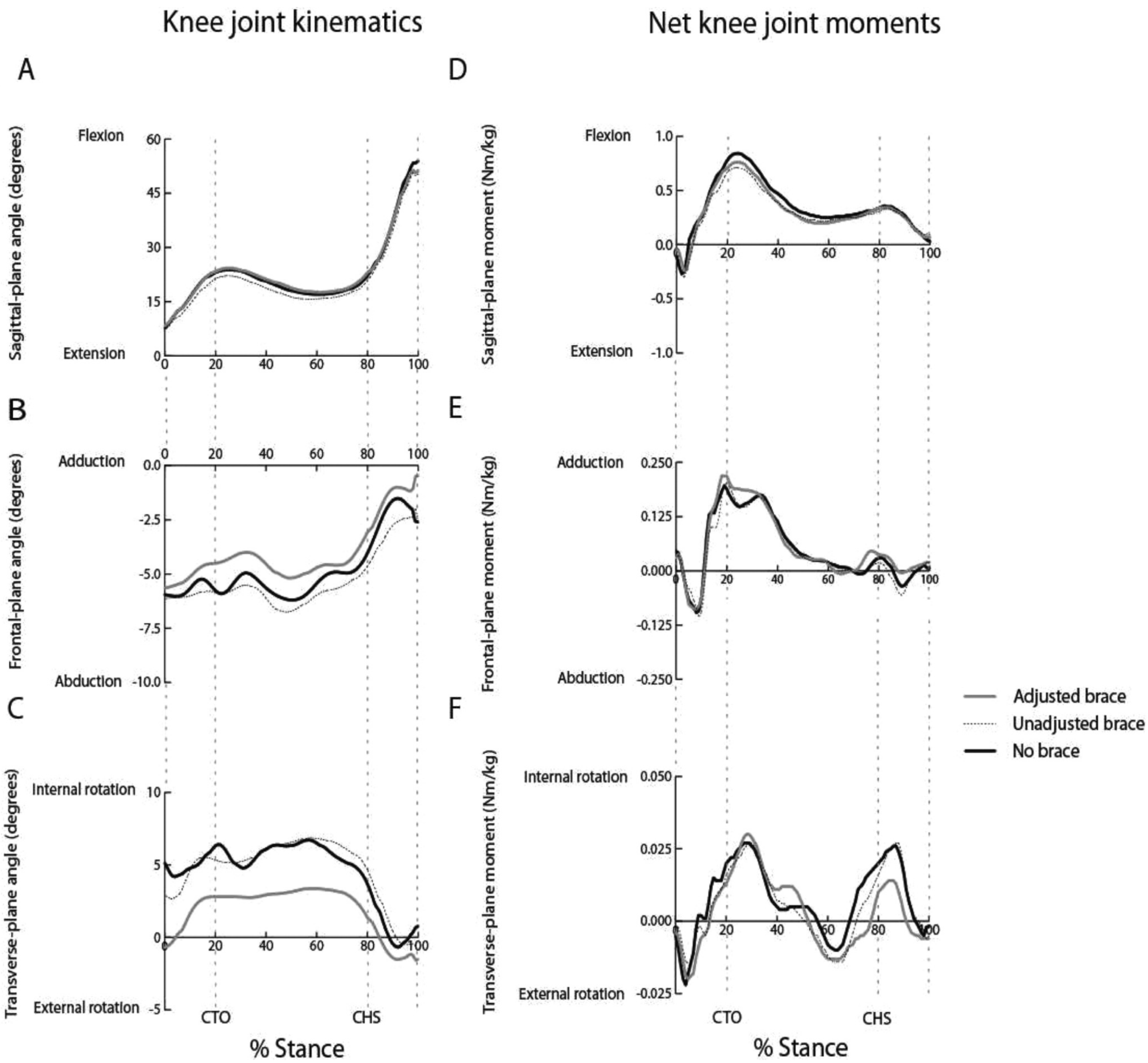

Figure 2. Knee joint kinematics and external net joint moments during the stance phase for the adjusted, unadjusted and no brace conditions. Knee joint kinematics and external net joint moments at contralateral toe-off (CTO) and contralateral heel strike (CHS) are shown with dashed lines.

were averaged over three trials and time-normalised to the stance phase (i.e., heel-strike to toe-off). Ground reaction force (GRF) and joint moments were normalized to body mass. The magnitude and timing of peak joint angles and net joint moments were identified at contralateral toe-off (CTO), as this represents the time of peak hip- and knee-joint moments[15].

Results

Compared to not wearing the brace, during the step-down task the participant reported reduced task-difficulty (no brace 74 mm, brace 33 mm), lower knee-instability (no brace 74 mm, brace 28 mm), increased knee-related confidence (no brace 75 mm, brace 26 mm), and no pain (no brace 3 mm, brace 0 mm) with the knee brace.

During walking, the GRFs were similar between the three test conditions (Figure 1). The varus brace resulted in immediate changes in knee kinematics. At CTO, no discernible differences were observed in the sagittal plane angles (Figure 2A), however a 24% reduction in the knee abduction angle was observed with the adjusted brace compared to the no-brace condition (Figure 2B). In the transverse plane, notable bracing effects were seen throughout stance phase (Figure 2C). At CTO, a 56% decrease in the internal rotation angle was noted

	No brace	Unadjusted	Adjusted
Flexion angle			
Contralateral toe off (degrees)	23.5	21.7	23.7
Peak value (degrees)	23.8	22.1	24.3
Time at peak (% stance)	25	24	25
External flexion moment			
Contralateral toe off (Nm/kg)	0.83	0.69	0.73
Peak value (Nm/kg)	0.84	0.71	0.76
Time at peak (% stance)	19	20	18
Abduction angle			
Contralateral toe-off (degrees)	5.91	5.86	4.49
Peak value (degrees)	6.20	6.76	5.19
Time at peak (% stance)	51	48	50
External adduction moment			
Contralateral toe-off (Nm/kg)	0.17	0.19	0.20
Peak value (Nm/kg)	0.20	0.20	0.22
Time at peak (% stance)	24	23	24
Internal rotation angle			
Contralateral toe off (degrees)	6.39	5.28	2.81
Peak value (degrees)	6.72	6.86	3.38
Time at peak (% stance)	57	58	59
External internal rotation moment			
Contralateral toe off (Nm/kg)	0.02	0.02	0.02
Peak value (Nm/kg)	0.03	0.03	0.03
Time at peak (% stance)	29	30	28

Table 1. Knee kinematics and external net moment data for the no brace, unadjusted and adjusted brace conditions.

with the adjusted brace (Table 1). Observation of the internal rotation angle (Figure 2C) throughout stance shows contrasting brace effects, decreased angles with the adjusted brace and increased angle with the unadjusted brace, compared to no-brace at contralateral heel strike (CHS).

The varus brace produced some subtle changes in net knee joint moments. In the sagittal plane at CTO, a decrease in the knee flexion moment was noted with the adjusted brace (12%) when compared to the no-brace condition (Table 1). A small increase in the external knee adduction moment was observed with adjusted brace condition (18%) when compared to the no-brace condition (Figure 2E). In the transverse plane, no discernible differences in the knee joint moments were observed between the three conditions at CTO (Table 1), but a decrease (Figure 2F) in the internal rotation angle (44%) was seen for the adjusted brace compared to the no-brace condition.

Discussion

We found that the varus brace produced immediate improvements in knee pain, stability, confidence, and task-difficulty during the step-down task. In addition, immediate changes in frontal and transverse plane knee biomechanics during walking that were more pronounced for the adjusted, than the unadjusted brace. While these results represent bracing effects for a single participant only, they provide preliminary evidence for the potential efficacy of a targeted brace for lateral TFJOA after ACL reconstruction.

Immediate improvements in the participant's perceived difficulty (44%), instability (46%) and knee-related confidence (35%) during the step-down test were observed with the varus brace, which may result from the physical and perceived support provided by the brace. Considering that perceptions of difficulty, stability, and confidence are integral to the performance of work, sporting, and daily-activities, the varus brace appears to have the potential to enhance physical function and quality-of-life in ACL reconstructed individuals with lateral TFJOA.

The adjusted brace reduced the knee abduction angle, which is important since valgus alignment is associated with greater risk of lateral TFJOA progression[16]. Considering that an intervention that increases the knee adduction moment may heighten the risk of medial TFJOA progression, it was important that there was no increase in flexion moment and the reduction in knee abduction angle did not translate to an excessive increase in peak knee adduction moment. Given no change in GRF magnitude (Figure 1), the brace likely shifted the center of pressure laterally, thus reducing the GRF moment arm about the knee joint center. In the transverse plane, the adjusted brace substantially reduced the knee internal rotation angle (Figure 2C). This is of note, as excessive knee external rotation has been reported in individuals after ACL reconstruction, which could plausibly result in adverse articular cartilage loading, leading to initiation of the knee OA process after ACL reconstruction[17]. Thus, knee bracing could represent a future intervention for reducing the onset and/or progression of OA in ACL reconstructed knees.

Our study provides preliminary data, which may lead to further investigation into the short and long term consequences of a knee brace in patients with lateral TFJOA after ACL reconstruction. While compliance with brace-wear is problematic[18] individuals with knee OA after ACL reconstruction are frequently too young for definitive surgical procedures and perhaps more likely to adhere to such interventions. At present, the desired biomechanical changes required to minimise lateral TFJOA development or progression are unknown. These ought to be investigated in future prospective studies.

Conclusion

In individuals with valgus alignment and predominant lateral TFJOA post-ACL reconstruction, a frontal-plane adjusted knee brace may be used as an intervention to alter gait biomechanics and reduce knee OA symptoms.

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