Comparison of three knee braces in the treatment of medial knee osteoarthritis

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ABSTRACT

Background: Conservative orthotic treatments rely on different mechanisms, such as three-point bending systems or hinges forcing external rotation of the leg and knee stabilization, to alter the biomechanics of the lower limbs and thus reduce knee loading on the affected compartment in patients with knee osteoarthritis (KOA). No previous study had compared the effects of these mechanisms on external loading and leg kinematics in patients with KOA.

Methods: Twenty-four patients with medial KOA (Kellgren–Lawrence grade II or III) wore three custom knee braces: a valgus brace with a three-point bending system (V3P-brace), an unloader brace with valgus and external rotation functions (VER-brace) and a functional knee brace used in ligament injuries (ACL-brace). Pain relief, comfort, lower extremity kinematics and kinetics during walking were compared with and without each knee brace.

Results: Knee pain was alleviated with all three braces (p < 0.01). The VER- and ACL-braces allowed a significant reduction in peak knee adduction moment (KAM) during terminal stance from 0.313 to 0.280 Nm/Bwaster (p < 0.001) and 0.293 to 0.268 (p < 0.05), respectively, while no significant reduction was observed with the V3P-brace (p = 0.52). Reduced knee adduction and lower ankle and knee external rotation were observed with the V3P-brace but not with the VER-brace. The ACL-brace did not modify lower limb kinematics.

Conclusions: No difference between the knee braces was found for pain reduction, discomfort or KAM. The VER-brace was slightly more comfortable, which could ensure better compliance with treatment over the long term.

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1. Introduction

The knee joint is specifically affected by osteoarthritis, and 12.1% of the population aged 60 years and older is affected by symptomatic radiographic knee osteoarthritis (KOA) [1]. The knee joint plays an important stabilizer and shock absorber role during gait [2], so KOA is a major cause of disability and leads to significant declines in activity among people over 50 years old [3]. The compartments of the knee are not all affected in the same way, and people are at 10 times more risk of having medial than lateral KOA [1,4]. Some authors have suggested that this differential effect on knee compartments could be due to the difference in weight distribution on the knee during gait. Indeed, during walking, the medial compartment supports 2.2 times as much loading as the lateral compartment [5,6].

Because no cure exists for osteoarthritis, non-pharmacological and pharmacological treatments are used to reduce pain and improve function and quality of life before surgery is resorted to [3,7]. However, to relieve pain in malaligned knees, it may be necessary to reduce the load on the affected compartment, which is why several conservative treatments aim to alter the biomechanics of the lower limbs [8,9].

A valgus knee brace is one of the non-pharmacological treatments recommended to manage medial KOA [7]. It uses a three-point bending system and a predetermined angulation of the brace hinge components [9] and generally relieves pain by 10% or more [10,11]. Furthermore, its use also reduces the medial/lateral knee loading ratio by nine to 30 percentage points [12] and the knee adduction moment (KAM) by 8% or more [13,14] during weight bearing on the affected leg.

One compensatory strategy often used to unload the medial compartment of the knee (i.e., reduce the second peak of KAM) is an increase in the toe-out angle of the weight-bearing foot during the stance phase [15]. By externally rotating the leg, toe-out gait alters the length of the ground reaction force lever arms acting on the knee joint.
in the frontal plane. Recently, an unloader knee brace with a mechanism that induces outward (valgus) displacement and external rotation of the leg when fully extended was found to reduce the second peak of KAM by 22% in patients with KOA [16]. One limitation on that study was the lack of a control group to assess the real benefits of the unloader brace.

It has been suggested that perception of pain relief and improved function among KOA patients could also be due to joint stability [10]. A functional knee brace used in ligament injuries, such as tears of the anterior cruciate ligament (ACL), could generate benefits by stabilizing the knee during walking, but to date no study has verified this hypothesis.

The purpose of this study was to compare the immediate effects on pain, comfort and medial knee loading during gait of three knee braces: a valgus knee brace with a three-point bending system (V3P brace), an unloader brace with valgus and external rotation functions (VER brace), and a functional knee brace used to stabilize the knee after ligament injuries (ACL brace), in patients suffering from medial compartment KOA. We hypothesized that both valgus braces (V3P and VER) would provide the same alleviation of pain and reduction in knee loading, but the ACL brace would not. Comfort would be better with the VER brace than with the V3P brace because of its smaller size and because the VER brace’s mechanism of action does not push on the knee joint in loading conditions.

2. Material and methods

2.1. Participants

Fourteen males and ten females with medial compartment KOA participated in this study. None of the participants had used knee braces before. The mean (SD) age, height, body mass and body mass index of participants were 57.2 (8.6) years, 1.68 (0.09) m, 89.3 (18.7) kg and 31.6 (5.2) kg/m², respectively.

Inclusion criteria were symptomatic medial KOA (Kellgren-Lawrence grade II or III) according to the American College of Rheumatology’s clinical and radiological criteria [2,17], knee pain > 31/100 (WOMAC), moderately active lifestyle, and varus knee alignment equal or superior to 2° (the mechanical tibiofemoral angle was measured on radiographs). The exclusion criteria were mild or severe KOA (Kellgren-Lawrence grade I or IV), rheumatoid arthritis or other inflammatory arthritis, avascular necrosis, history of periarticular fracture or septic arthritis, bone metabolic disease, pigmented villonodular synovitis, caritial disease, neuropathic arthropathy, synovial osteochondromatosis, total or partial knee arthroplasty, flexion contraction of 15° or contralateral knee greater than 15°, hip or ankle joint damage with mobility limitation, obesity (BMI ≥ 40), intra-articular corticosteroid injection in the affected knee during the previous two months, and reduced mobility (Charlson class C).

Patients were recruited through a campus mailing list. Patients diagnosed with KOA by their family physicians were asked to call a research nurse, who screened for their level of disability and knee pain using the WOMAC score. Then a radiological assessment, evaluated by an orthopedic surgeon, was necessary to verify the inclusion and exclusion criteria. Once patients consented to take part in the study, they were referred to an orthotist to be fitted with custom braces and then, two weeks later, to the gait laboratory for testing [Fig. 1]. Ethical approval was obtained from the institutional ethics committee, and written informed consent was obtained from all participants.

2.2. Apparatus

Kinematic data were acquired by an optoelectronic motion analysis system composed of 13 cameras (FLEX:V100R2, NaturalPoint Inc., Corvallis, OR, USA), capture software (Capture 2D™, C-Motion Inc., Germantown, MD, USA) and 42 reflective markers: 26 were attached to anatomical landmarks (iliac crest, anterior superior iliac spine, posterior superior iliac spine, greater trochanter, medial and lateral femoral epicondyle, fibula apex of lateral and medial malleolus, heel and medial and lateral forefront of the shoe) and four rigid marker clusters made up of four markers apiece were affixed to the thigh and shank of both legs according to the CAST protocol [18,19]. When knee braces were worn, femoral epicondyle markers were attached directly on the knee brace, and then virtual landmarks were created to relocate the knee markers. Moreover, two force plates (Model BP400060NC, AMTI, Advanced Mechanical Technology Inc., Watertown, MA, USA) were used to acquire kinetic data. Kinematic data were sampled at 100 Hz while kinetic data were sampled at 1000 Hz. Finally, a 3.5-meter instrumented walkway measured natural gait velocity and cadence (GAITRite, CIR System, Sparta, NJ, USA).

Three customized knee braces were made for each participant (Fig. 2; Orthoconcept Inc., Laval, QC, Canada): a functional knee brace to stabilize the knee (ACL brace), a valgus brace designed to work with a three-point bending force mechanism (V3P brace), and an unloader brace with valgus and external rotation functions (VER brace).

For the V3P brace, the three forces are generated by the tension of the straps and forces applied to the thigh, knee joint and leg [9]. Participants were instructed to tighten the diagonal strap so as to put pressure on their knee, but in such a way that they could wear it comfortably for several hours. The VER brace was a new-generation brace with a different mechanism of action, which is described in detail elsewhere [16]. Briefly, this unloader knee brace is composed of a semi-rigid anterior femoral band and a rigid anterior tibial band (Fig. 2D). This new brace is designed to work by creating a valgus (i.e., distraction between femur and tibia) and applying a slight external rotation to the leg during knee extension. These actions are performed by a medial trammel hinge, which stretches out the medial components during knee extension, and a lateral trammel hinge, which moves the brace’s center of rotation backward. Comfort is ensured by copolymer anti-slip protection on the anterior tibial band, a breathable lining on the femoral band, and silicone padding on each strap. The ACL and VER braces were approximately 5% and 25%, respectively, smaller and narrower than the V3P brace. For instance, for a person 1.71 m tall, the customized V3P brace was 17.8 cm wide and 37.5 cm long, and the customized VER brace was 15.2 cm wide and 28.1 cm long.

2.3. Experimental procedure

A crossover study was done to evaluate the effects of wearing the three types of knee braces over a three-month period; each period of wear was followed by a two-week washout period without a brace. Knee brace order was randomized and each patient underwent a biomechanical assessment in the gait laboratory. The mechanisms and functions of each brace were not explained to the participants. The present study focuses on the immediate effects of the knee braces (first visit for each brace) and examines and describes the mechanisms explaining KAM reduction during the stance phase of gait among medial KOA patients.

At the first assessment, participants were instructed to perform six gait trials without the knee brace on the instrumented walkway at a self-selected regular gait speed, starting to walk 3 m before they stepped onto the walkway in order to reach a steady-state walk when their steps were recorded. These trials were processed immediately and determined the individual natural gait cadence for the duration of the study. Then, in all sessions, static model and gait analysis with and without the knee brace were done. Each patient walked on an 8-m walkway with the force plates located 2.75 m and 3.40 m from the start. Participants were instructed to walk following the beat of a metronome, which was adjusted to their self-selected cadence, as measured at the first assessment on the instrumented walkway. Before official data gathering began, several trials were carried out to determine the exact distance of the start so participants’ heel-strikes would hit each force plate without modifying their gait pace. Ten trials were carried out in
each condition and conditions were randomized. After each trial condition tested, knee pain and knee orthosis discomfort were assessed with two 20-cm visual analogue scales (VAS). Results are expressed in percentages; higher scores indicate greater pain and greater discomfort on the pain and comfort scales, respectively.

2.4. Data reduction

Visual 3D software (Version 4.96, C-Motion Inc., Germantown, MD, USA) was used to process kinematic and kinetic data. Raw data from markers and force plates were filtered at 6 Hz with a low pass Butterworth filter [20,21]. Center of pressure displacement was calculated from force plate signals. Joint angles were calculated using Cardan angles with an X–Y–Z order of rotation, equivalent to the Joint Coordinate System [1,4,22]. External joint moments were calculated using three-dimensional inverse dynamics and normalized to body weight (Bw * Ht). Joint moments were expressed using the distal segment coordinate system. A custom-written software program (Matlab 2007b, Mathworks Inc., Natick, MA, USA) was used to compute gait variables and find the KAM curve (Table 1). KAM normally exhibits two peaks during the stance phase; the magnitude of the first peak is strongly correlated with increased disease severity, pain, and rate of disease progression [23,24]. The shape of the KAM curve over the gait cycle has been shown to correlate with the shape of the medial compartment contact force curve over the same cycle [24,25]. Recently, Walter et al. [25] made direct measurements of medial compartment contact forces at the knee during gait and showed that both peaks of medial contact force were best predicted by a combination of first and second peaks of KAM values and peak absolute values of the knee flexion moment. These three parameters and KAM angular impulse, which reflects the total loading during the entire stance phase [26], were used to characterize knee loading. Other secondary variables are presented in Table 1.

2.5. Statistical analysis

Two analyses were performed: (1) one to evaluate whether each brace changed outcomes compared to its baseline; and (2) one to evaluate whether outcome changes differed depending on the brace used. For the first analysis, paired t tests were used to compare each brace with its baseline in the gait data while the Wilcoxon Signed Ranks test was used on the pain VAS score because it did not respect the normal Gaussian distribution. Comfort was not studied in the first analyses because no comfort score was collected in the without brace condition. For the second analysis, we subtracted the brace value from its baseline value to perform a one-way repeated measures analysis of variance (ANOVA) between brace and baseline values in gait data. Pain and comfort VAS scores did not respect the normal Gaussian distribution, so a non-parametric Friedman test was used to compare them between conditions. The Bonferroni correction was employed as a post hoc test after the ANOVA. Statistical analysis was performed using STATISTICA.

Fig. 1. Flow of participants through trial.
Fig. 2. Picture of the three knee braces. (A) ACL brace (ACL brace, Orthoconcept Inc., Laval, QC, Canada). (B) Valgus brace with three-point bending force mechanism (V3P brace, Orthoconcept Inc., Laval, QC, Canada). (C) Unloader brace with valgus and external rotation functions (VER brace, Orthoconcept Inc., Laval, QC, Canada). (D) Detailed description of the VER brace.

Table 1: Description of biomechanical variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
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<tr>
<td>First- and second-peak KAM</td>
<td>Maximum adduction moment of the knee during the first and last 50% of the stance phase, respectively</td>
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<tr>
<td>KAM angular impulse</td>
<td>Area under the knee adduction moment–time graph during the stance phase.</td>
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<tr>
<td>Gait velocity</td>
<td>First derivative of the middle of the ASIS–PSIS position on two consecutive strides at mid-distance on the walkway</td>
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<tr>
<td>Step length</td>
<td>Antero-posterior distance between right and left heel markers at heel strike</td>
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<tr>
<td>Step width</td>
<td>Medio-lateral distance between right and left heel markers at heel strike</td>
</tr>
<tr>
<td>Foot progression angle</td>
<td>Mean angle between the direction of progression and a reference line on the sole of the foot during the stance phase</td>
</tr>
<tr>
<td>Knee adduction angle</td>
<td>Mean angle of the shank segment relative to the thigh segment in the frontal plane during the stance phase</td>
</tr>
<tr>
<td>Ankle external rotation angle</td>
<td>Mean angle of the foot segment relative to the shank segment in the transverse plane during the stance phase</td>
</tr>
<tr>
<td>Hip external rotation angle</td>
<td>Mean angle of the thigh segment relative to the pelvis segment in the transverse plane during the stance phase</td>
</tr>
<tr>
<td>Frontal ground reaction forces</td>
<td>Frontal (sum of medio-lateral and vertical) ground reaction force at the first and second KAM peaks normalized according to body weight</td>
</tr>
<tr>
<td>Knee–center of pressure distance</td>
<td>Distance between the knee joint center and the center of pressure at the first and second KAM peaks</td>
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KAM = knee adduction moment; ASIS–PSIS = anterior superior iliac spine and posterior superior iliac spine.

Gait velocity was measured in m·s$^{-1}$, step length and step width in cm, angles in °, ground reaction forces in N, external moment in Nm/Bw + Ht, angular moment impulse in Nm·s/Bw + Ht and lever arm and knee–center of pressure distance in mm.
8.0 (StatSoft, Inc., Tulsa, OK, USA). The level of significance was set at p < 0.05 for all tests.

3. Results

Three participants withdrew from the study after initial recruitment for personal reasons (Fig. 1).

3.1. Braces vs. baseline

Regarding primary outcomes, knee pain was relieved by all the braces (p < 0.01; Table 2) while KAM impulse was decreased only with the VER brace (−6%; p < 0.01; Table 3). No brace affected the first-peak KAM, but the second peak was decreased in the ACL and VER brace conditions (−8.5% with ACL brace and −10.5% with VER brace; p = 0.04 and p < 0.001, respectively; Table 3). Knee–center of pressure distance at the first and second peaks and frontal ground reaction forces at the second peak were reduced with the VER brace (p = 0.02, p = 0.02 and p = 0.05, respectively; Table 3). A decrease in gait velocity was observed only in the V3P brace condition (−1%; p = 0.03; Table 2). The V3P brace led to inferior knee adduction and ankle external rotation and superior hip external rotation (p < 0.01, p < 0.01 and p = 0.01, respectively; Fig. 3). The VER brace increased knee and ankle external rotation and reduced hip external rotation (p < 0.01; Fig. 4). The ACL brace did not modify knee adduction or ankle, knee and hip rotation angles (p > 0.10).

3.2. Comparison between braces

No differences between orthoses were found for pain reduction, discomfort, KAM or variables affecting KAM (step length and width, foot progression angle, knee–center of pressure distance and frontal ground reaction forces) (p > 0.16; Tables 2 and 3). On the other hand, differences were found between the V3P and VER braces in the changes in knee joint kinematics (Fig. 4). For knee adduction, a reduced value was observed with the V3P brace but not with the VER brace (−1.1° vs. −0.2°, respectively; p = 0.01).

Concerning external rotation, a greater ankle external rotation was seen in the ACL and VER brace gaits than in the V3P brace gait (1.3° and 2.0° vs. −2.0°; p < 0.01 and p < 0.001, respectively). The VER brace also caused a greater change in external rotation of the knee than the V3P brace (1.7° vs. −0.3°; p = 0.02). In the V3P brace gait, the hip's external rotation was greater than in the other brace gaits (2.4° vs. −1.3° and −3.2°; p = 0.03 and p < 0.001, respectively).

4. Discussion

Our study aimed to compare the immediate effects on pain, comfort and medial knee loading of a custom-fitted unloader knee brace with valgus and external rotation functions, a functional knee brace used for ligament injuries and a valgus three-point bending system knee brace. Despite the lack of any statistically significant difference between braces in terms of knee loading and discomfort, we noted that two of the braces – the VER and ACL braces – allowed for a statistically significant decrease in knee joint loading during the terminal stance phase of gait. All three braces resulted in immediate pain relief.

Pain is the major complaint made by patients suffering from KOA and is the principal cause of disability and loss of autonomy in senior patients [2,5,6,27]. Consequently, recommendation guidelines for the management of KOA focus primarily on pain relief and functional improvement [3,7,28]. Our results showed that all the braces we tested alleviated pain.
but the two valgus braces seemed to be more effective (−35%; p < .01). The effectiveness of valgus knee braces with a three-point bending force mechanism in pain relief has been widely demonstrated, and our V3P brace result was similar to those found in previous studies of such braces [8–10,29]. The reduction in pain following the use of a brace with valgus and external rotation functions was also reported in a previous study [16], whereas, to our knowledge, the treatment of KOA with a brace intended for ligament injuries had never been tested. In spite of the effectiveness of valgus knee braces with a three-point bending force mechanism for pain relief, several recent studies have noticed that, when such braces are provided for the management of KOA, they tend to have low daily use (<4 h/day) and poor compliance rates [7, 14,29–31]. Patients’ disinclination to wear these knee braces for long periods is mainly due to the lack of noticeable benefits, poor fit and aesthetic aspects of the braces (bulkiness, weight, size) [31–33]. In this study, immediate discomfort did not differ significantly between braces. However, the discomfort level was reduced by 15 percentage points (i.e., 50%) with the VER brace (and nine percentage points with the ACL brace) compared to the V3P brace. In a footwear study, comfort was assessed by the clinically minimal difference in rating on the VAS [10,11,34]. That study observed that the clinically minimal change in footwear comfort measured with the VAS was nine percentage points. Extrapolating this data to ours could suggest that, even though no statistically significant difference was noticed, the observed difference could be clinically relevant. These reasons, plus the fact that the unloaded knee brace with valgus and external rotation is smaller, could favor better patient compliance with this brace. Thus, the results of this study concerning subjective pain and comfort levels suggest that the VER brace has the best potential among the three braces tested to improve the quality of life of patients with medial KOA.

Alleviation of knee pain is the major concern in medial KOA management. Several non-pharmacological treatments, such as valgus knee braces or lateral wedged insoles, aim to alter the biomechanics of the legs to decrease medial knee loading. Depending on the brands of knee braces, parameters and studies, valgus braces with a three-point bending force mechanism have been found to reduce KAM by about 10% [12–14]. This kind of brace works by reducing the knee adduction angle, which decreases the distance between the center of pressure and center of rotation of the knee joint and thus the lever arm between the center of rotation and the frontal ground reaction force vector [9,13,14]. Unlike previous studies, we did not find a significant reduction in medial knee loading with the V3P brace. This difference could be due to a smaller correction, with only a 1° reduction in the knee adduction angle during gait. The only study measuring the knee adduction angle correction during gait reported a 2.6° reduction for a significant (9.5%) decrease in the KAM [1,11,12,24,25,35]. The smaller correction in our study might be explained by the diagonal strap tension, which might not be tight enough, leading to a low pressure point on the knee. In addition, no valgus correction was incorporated into the V3P brace. Pollo et al. [9] showed that the amount of valgus correction incorporated into the brace was associated with the amount of unloading of the affected compartment and that increasing the strap tension did not have as great an effect as increasing the valgus angulation.

The decrease in the knee adduction angle must apply pressure on the anatomic knee landmarks [2,9,33], which may cause discomfort for patients, usually proportionate to the deformity correction molded into the custom fit of the brace [12]. The VER brace avoids this contact pressure and uses a different mechanism: induced valgus (distraction between femur and tibia segments) and external rotation of the knee joint. Theoretically, distraction of the medial knee joint when the foot contacts the ground could reduce the force impact on the joint while external rotation allows for a more toe-out gait (increased foot progression angle [16]). A toe-out gait is known to induce a lateral shift in the center of pressure, reducing the knee lever arm [1,4,36–39]. As expected, a greater external rotation of the knee and decreased knee loading during the entire stance phase of gait were observed with the VER brace. The superior knee external rotation was supplemented by a larger ankle external rotation. However, contrary to our hypothesis and to the results of a previous study [16], the foot progression angle was not affected because of compensation at the hip joint level. So the decrease in knee joint loading with the VER knee brace could be due to the increased step width and the reduced frontal ground reaction force vector. However, although these two parameters are almost certainly involved, the results for the other two knee braces lead us to focus on the axial rotation of the three lower limb joints.

In comparing all the braces, we find that the KAM peak during the late stance phase of gait, at push-off, is reduced with the ACL and VER braces, which amplify the external rotation of the foot and internal rotation of the hip more than the V3P brace. This external rotation of the foot progression angle could induce weight bearing on the medial side of the foot and thus decrease the KAM.

Fig. 3. External knee adduction moment during the stance phase of gait in the with and without (W/O) knee brace conditions for each of the three braces: ACL brace, V3P brace and VER brace.

Fig. 4. Change in the mean knee adduction and ankle, knee and hip rotation angles during gait with the three knee braces. The ACL brace was the stabilization brace, the V3P brace was the three-point bending brace and the VER brace was the unloader brace with valgus and external rotation functions. A positive value for knee adduction angle means an increase in adduction. A positive value for ankle, knee and hip rotation means an increase in external rotation. Error bars correspond to the 95% confidence interval. add. = adduction; rot. = rotation. *= p < 0.05; ** = p < 0.01; *** = p < 0.001.
malalignment, the femoro-patellar joint is typically affected. Once the knee brace guides the leg into external rotation, the femoro-patellar joint may be better aligned and thus may contribute to the alleviation of knee pain. Furthermore, balance and proprioception are affected by this external rotation, which may in turn affect the subjective comfort of the brace.

In spite of their effectiveness, valgus knee braces are not always prescribed due to patients’ poor compliance with the treatment over time. Indeed, longitudinal studies of these braces show that 42% of patients stop wearing them in the initial year with 64% of them in the first three months [33]. These withdrawals can be explained by a negative score for the advantage/drawback ratio [30,33], which seems to be influenced by brace comfort and size [36–38]. These drawbacks might lead to immediate negative feelings concerning the knee brace and its effectiveness. In the present study, eight out of 21 participants (38%) reported greater discomfort with the V3P brace than the maximum discomfort score observed with the VER brace. Recent studies have considered improving the comfort of knee braces by adding pneumatic bladders or more adjustable parameters at the three pressure points, but without changing their intrinsic mechanisms [1,38,40,41]. Although their results are encouraging, past protocols were only carried out with finite-element analysis or a small number of patients (n < 10).

In our study, we did not wear standardized footwear and their shoes may have influenced the amplitude of the joint moments calculated. However, our study design compared participants within repeated conditions, so the statistical results should remain unchanged. Walter et al. [25] showed that reducing the peak KAM does not necessarily guarantee a corresponding decrease in peak medial compartment contact force and that a corresponding increase in peak knee flexion moment is the most likely explanation. In the study reported on here, there was no difference in peak absolute knee flexor moment between the knee braces tested (p > 0.96). In the absence of any change in peak absolute knee flexor moment, our results remain consistent with the idea that a reduced peak KAM is associated with a corresponding decrease in knee loading. Finally, a selection bias exists in studies relying on campus mailing, as only the most motivated individuals are likely to contact the study team. Thus, subjective reporting by patients may be rather optimistic and their feelings may be better than those of the population at large.

One of the strengths of our study is the experimental design and crossover comparison of three different types of braces. This allowed us to better evaluate the relative importance of these mechanisms in explaining the functional benefits of the three knee braces.

Although an increase in walking speed constitutes an important functional gain following the prolonged use of a knee brace, it adds a confounding variable that may mask the real effect of the brace [16]. For this reason, gait velocity was controlled during the different experimental sessions to isolate the effect of the brace.

The functional knee brace used in ligament injuries also provided non-negligible benefits for patients with KOA. This brace, which affected leg kinematics very little during walking, had positive effects on knee loading, particularly with regard to the reduction in the second peak of KAM. Perceived pain relief and improved function among KOA patients could be due to enhanced joint stability [10]. Other mechanisms, such as improved proprioception and motor control, could also explain these results [42]. These causal agents were not quantified in this study. In light of the subtle differences between the various braces, the explanation related to joint stability represents a promising avenue.

In conclusion, the three braces provide similar pain relief and improvement in function during gait in KOA patients. The VER knee brace with induced valgus and external rotation to the leg during knee extension offers a slight comfort advantage, particularly because of its smaller size, which could result in better compliance with treatment over the long term. However, the effects of this brace on daily wear and compliance over the medium term remain to be confirmed in future studies.

Conflict of interest

None of the authors have any employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations or received grants or other funding that are related to this study.

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