The Effect of Valgus Knee Bracing on Adduction Moment, Pain, and Physical Function in Older Adults with Medial Compartment Knee Osteoarthritis: A 12-months Follow-Up Study

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Abstract

Introduction: Knee osteoarthritis (OA) is a leading cause of disability in the medial compartment of knee, where increased knee adduction moment (KAM) exacerbates disease progression. Valgus knee bracing is a non-surgical intervention aimed to reducing KAM, alleviating pain, and improving function. **Material and Methods:** This single-group intervention pre and posttest design study aimed to evaluate the effectiveness of valgus knee bracing over a 12 months follow-up period on adduction moment, pain, and physical function in older with medial compartments OA. Twenty-one patients with grade 2 or 3 medial knee OA were enrolled. All participants used a valgus knee brace for 12 months. KAM, pain, satisfaction and functional performance were assessed at baseline and 12 months. **Results:** Significant reductions in KAM (28%, *P*=0.02) and pain (25%, *P*=0.00) were observed after 12 months of using valgus knee bracing. Functional improvement was also significant (41%, *P*=0.005). Patient satisfaction showed a 9% increase (*P*=0.078) too. **Conclusion:** Valgus knee bracing significantly reduces KAM and pain while improving motor function in patients with medial compartment knee OA. However, patient satisfaction was moderate which indicate that its need improvement comfort in brace design. These findings highlight the potential of valgus bracing to delay the need for surgical intervention, offering a conservative treatment option for managing knee OA.

Keywords: Biomechanical Phenomena; Knee; Osteoarthritis; Orthotic Devices; Pain; Physical Functional Performance; Patient Satisfaction

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Introduction

Knee osteoarthritis (OA) is one of the most prevalent musculoskeletal disorders in worldwide, affecting approximately 10% of men and 13% of women over the age of 60 (1). It is characterized by the progressive degeneration of articular cartilage, leading to pain, stiffness, and functional impairment. Among the various compartments of the knee, the medial compartment is most commonly affected due to higher load distribution during weight-bearing activities (2). This disproportionate loading results in increased knee adduction moment (KAM). knee adduction moment is a biomechanical parameter reflecting the inward rotational force exerted on the knee joint during gait. Elevated KAM is strongly associated with the progression of medial compartment knee OA, exacerbating cartilage wear and accelerating joint degeneration too(3). The biomechanical rationale for valgus bracing lies in its ability to apply an external valgus moment to the knee by redistributing load from the medial to the lateral compartment. This reduces KAM, decreases stress on the medial compartment, and may slow the disease progression.

The management of knee OA is multifaceted, ranging from conservative measures such as rehabilitation interventions and pharmacological interventions to surgical options like total knee arthroplasty (4). However, surgical interventions are often reserved for advanced cases due to inherent risks, high costs, and prolonged recovery periods. Non-surgical interventions, such as valgus knee bracing, offer a less invasive technic to manage

medial compartment of knee OA (5). Alternative non-surgical interventions, such as lateral wedge insoles and gait modification, have also been explored. While lateral wedge insoles aim to reduce KAM by altering foot alignment, they may not provide the same level of mechanical correction as valgus bracing. Gait modification strategies, such as toe-out walking, can reduce KAM but may be difficult to sustain over long periods. Valgus bracing offers a more consistent and adjustable approach to load redistribution (6).

Despite a growing evidences supporting the efficacy of valgus knee bracing, gaps remain in the literature. While short effect studies have demonstrated reductions in KAM and improvements in pain and motor function (7, 8), the long-term effects of valgus bracing on disease progression and patient satisfaction are less understood. Variability in brace design, patient adherence, and the biomechanical mechanisms underlying the intervention's effectiveness warrant further investigations (9, 10).

This study seeks to address these gaps by evaluating the effects of valgus knee bracing on KAM, pain, and functional performance over a 12 months follow-up period in older adults with medial compartment Knee OA. The findings of this study may have the potential to inform clinical practice, offering a non-surgical approach that balances biomechanical efficacy with patient comfort and satisfaction.

Material and Methods

Study Design and Participants

This was a single-group intervention study involving 21 patients with grade II or III medial knee OA, classified according to the Kellgren-Lawrence scale [11]. Participants were recruited from orthopedic clinics in Tehran, Iran, and included adults aged 50 to 75 years with a confirmed diagnosis of medial compartment knee OA, as determined by radiographic imaging and orthopedist diagnosis. To ensure the study focused on individuals with moderate to severe OA, only those meeting these specific diagnostic criteria were included. Additionally, participants were required to demonstrate the ability to walk independently without the use of assistive devices, ensuring that functional assessments were conducted under consistent conditions. All participants provided written informed consent and expressed a willingness to adhere to the study protocol, including the consistent use of a custom-fitted valgus knee brace for 12 months. Individuals were excluded if they had a history of knee surgery or significant knee trauma. Participants with severe comorbidities affecting mobility, such as advanced cardiovascular disease or neurological disorders, were also excluded to minimize the influence of unrelated health conditions. The use of other orthotic devices during the study period was prohibited to ensure that observed effects could be attributed solely to the valgus knee brace. Finally, individuals who were unable or unwilling to comply with study requirements, including daily brace usage and follow-up assessments, were excluded to maintain the integrity of the study design and data collection.

Participant Recruitment and Consent

Participants were recruited through referrals from orthopedic specialists and advertisements in local clinics. Eligible patients were provided with detailed information about the study, including its objectives, procedures, potential risks, and benefits.

Intervention: Valgus Knee Brace

The valgus knee brace used in this study was a custom-fitted device made of lightweight neoprene, designed to apply a valgus moment to the knee. The brace featured an adjustable strap system to ensure proper fit and alignment, with a valgus correction angle of 4-8 degrees, depending on individual patient needs. Patients were trained to wear the brace for 6-8 hours daily based on clinical guidelines (Figure 1).

Execution of the Intervention

At the beginning of the study, all participants underwent a comprehensive baseline assessment to establish their initial KAM, pain levels, functional performance, and overall satisfaction. These assessments were conducted by a trained physiotherapist with expertise in biomechanics and orthopedic rehabilitation, ensuring consistency and accuracy in data collection.

KAM was measured using a state-of-the-art motion analysis system (Vicon, UK) synchronized with a force plate (Kistler, Switzerland). Participants were asked to walk at a self-selected pace across the force plate while the motion capture system recorded their gait kinematics and kinetics. This method has been widely validated in previous studies for its reliability in assessing knee joint loading in patients with osteoarthritis. Pain levels were evaluated using the VAS, a well-established tool for quantifying pain intensity subjectively, with scores ranging from 0 (no pain) to 10 (worst imaginable pain) (11). Functional performance was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire, which evaluates pain, stiffness, and physical function in patients with knee OA. The WOMAC has demonstrated high reliability and validity in both Western and Iranian populations, making it a suitable tool for this study (12).

Patient satisfaction with the valgus knee brace was measured using a 5-point Likert scale, ranging from 1 (very dissatisfied) to

Table 1. Baseline Characteristics of Participants

Characteristic	Mean (SD)
Age (years)	59.2 (8.1)
BMI (kg/m²)	28.5 (3.2)
KAM (Nm/kg)	0.69 (0.12)
Pain (VAS)	7.3 (0.8)
Physical Function WOMAC	64.9 (21.5)

Visual Analog Scale: VAS, Western Ontario and McMaster Universities Osteoarthritis Index: WOMAC

Table 2. **Mean (SD)** of changes in Outcome Measures after 12 months

Outcome Measure	Baseline	12 months	Change (%)	*P*-value
KAM (Nm/kg)	0.69 (0.12)	0.49 (0.16)	28%	0.02
Pain (VAS, 0-10)	7.3 (0.8)	5.4 (0.9)	25%	0.00
Physical Function (WOMAC, 0-100)	64.9 (21.5)	38.4 (7.8)	41%	0.005
Satisfaction (Likert, 1-5)	3.5 (0.5)	3.8 (0.4)	9%	0.078

*Visual Analog Scale: VAS, Western Ontario and McMaster Universities Osteoarthritis Index: WOMAN. **Significance level< 0.05***

5 (very satisfied). This scale has been previously used in similar studies to assess patient-reported satisfaction with orthopedic interventions (13).

To ensure the reliability of the measurements, all equipment was calibrated according to manufacturer guidelines before each testing session. Additionally, the assessor underwent rigorous training to standardize testing procedures and minimize inter-rater variability.

***Brace Fitting and Training*:** Each participant was fitted with a valgus knee brace by a trained Orthotist. Patients received detailed instructions on wearing and adjusting the brace. They were also provided with a logbook to record daily usage and any discomfort or issues encountered.

***Follow-Up Assessment*:** After 12 months, participants returned for a follow-up evaluation. The same outcome measures (KAM, VAS, WOMAC, and Likert scale) were reassessed to determine the effects of the intervention.

Marker Setting and Motion Analysis Setup

For KAM measurement, reflective markers were placed on specific anatomical landmarks of the lower extremities according to the Helen Hayes marker set protocol (14). This protocol includes markers on the anterior superior iliac spines (ASIS), posterior superior iliac spines (PSIS), lateral femoral epicondyles, lateral malleoli, and the second metatarsal heads. Additional tracking markers were placed on the thigh and shank segments to capture three-dimensional motion during gait. The motion analysis system (Vicon, UK) consisted of six infrared cameras with a sampling frequency of 120 Hz, synchronized with a force plate (Kistler, Switzerland) to record Ground Reaction Forces (GRF). Participants were instructed to walk at a self-selected speed along a 10-meter walkway, and data from three successful trials were averaged for analysis.

Statistical Analysis

Data were analyzed using paired t-tests to compare baseline and post-intervention outcomes, including KAM, pain levels (VAS), functional performance (WOMAC), and patient satisfaction (Likert scale). Prior to conducting the t-tests, the normality of the data was assessed using the Shapiro-Wilk test. All variables were found to be normally distributed, satisfying the assumption for parametric testing. A p-value of <0.05 was considered statistically significant, indicating that the observed changes were unlikely to have occurred by chance. All statistical analyses were performed using $SPSS_{22}$ software (version X, IBM Corp., USA), and results were reported as mean ± standard deviation (SD) for continuous variables.

Results

Table 1 presents the baseline characteristics of the 21 participants enrolled in the study. The mean age was 59.2 years, with a gender distribution of 4 males and 17 females. The mean Body Mass Index (BMI) was 28.5 kg/m².The baseline KAM was 0.69 Nm/kg, and the mean pain score on the VAS was 7.3. The WOMAC function score mean 64.9, indicating moderate functional impairment.

Table 2 summarizes the changes in outcome measures after 12 months of valgus knee bracing. KAM decreased by 28% (*P*=0.02), indicating a significant reduction in medial compartment load. Pain, measured by the VAS, decreased by 25% (*P*=0.00), showing a significant improvement in pain levels. Functional performance, assessed using the WOMAC questionnaire, improved by 41% (*P*=0.005), reflecting enhanced ability for doing daily activities. Patient satisfaction, increased by 9% (*P*=0.078), though this improvement was not statistically significant.

Discussion

The results of this study demonstrated that valgus knee bracing is an effective non-surgical intervention for reducing KAM, alleviating pain, and improving physical functional outcomes in elders with medial compartment knee OA. The 28% reduction in KAM aligns with previous studies, highlighting the biomechanical efficacy of valgus bracing in redistributing load away from the medial compartment (15, 16). This reduction in KAM is particularly significant, as elevated KAM is a key driver of disease progression in medial compartment knee OA. By reducing the load on the medial compartment, valgus bracing may help slow down the degeneration of cartilage and delay the need for surgical intervention (17).

Pain reduction was also notable, with a 25% decrease in VAS scores. This finding supports the hypothesis that reduced KAM alleviates pain by decreasing stress on the medial compartment of Knee. The reduction in pain is likely multifactorial, involving both biomechanical and neuromuscular mechanisms. For instance, the redistribution of load may reduce inflammation and mechanical irritation in the medial compartment, while improved alignment of the knee joint may enhance proprioception and neuromuscular control, further contributing to pain relief (17, 18).

Physical function improvement showed a 41% increase, indicating that valgus bracing not only reduces pain but also enhances patients' ability for doing daily activities. This improvement in physical function is likely mediated by the combined effects of reduced pain and improved joint mechanics. By alleviating pain and improving joint alignment, valgus bracing may enable patients to engage in physical activities with greater ease, thereby enhancing their overall quality of life (19, 20) .

However, patient satisfaction with the brace was moderate, with only a 9% increase on the Likert scale. While this improvement was not statistically significant, it suggests that patients generally found the brace beneficial, though some discomfort or inconvenience may have limited satisfaction. The moderate level of patient satisfaction highlights the need for improved comfort and usability in brace design. Factors such as brace weight, adjustability, and ease of use are likely to influence patient adherence and satisfaction (21). Future research should focus on optimizing these aspects of brace design to enhance patient acceptance and long-term adherence. Potential reasons for moderate satisfaction include brace discomfort, difficulty with daily use, and challenges with adjustability. Future brace designs should focus on improving comfort, reducing weight, and enhancing ease of use to increase patient adherence and satisfaction.

While the study demonstrated overall improvements in KAM, pain, and physical function, it is important to consider potential differences based on gender and BMI too. In this study, the gender distribution was not appropriate and equal, with 4 males and 17 females, reflecting the higher prevalence of knee OA among women. Additionally, the mean BMI of participants indicating that most participants were overweight, which may influence the biomechanical effects of bracing. Future studies should explore these factors in greater detail to better understand their impact on treatment outcomes.

While this study provides valuable insights into the effectiveness of valgus knee bracing for medial compartment knee OA, several limitations should be acknowledged: The study included only twenty one participants, which may limit the generalizability of the findings. A larger sample size would provide more robust statistical power and allow for subgroup analyses. The absence of a control group limits the ability to attribute observed changes solely to the intervention. Future studies should include a control group to account for placebo effects and natural disease progression. Patient compliance was self-reported subjectively and not objectively monitored. Future studies should use wearable sensors or other methods to track brace usage. in this study a single type of valgus knee brace was used that variations in brace design, such as different materials or adjustment mechanisms, may influence outcomes and should be explored in future research.

Conclusion

Valgus knee bracing is an effective non-surgical intervention for reducing KAM, alleviating pain, and improving physical function in elders with medial compartment knee OA. The findings of this study demonstrated significant reductions in KAM and pain, as well as improvement in physical function after 12 months of brace use. This study confirmed and highlight the biomechanical and clinical benefits of valgus bracing in elders with medial compartment knee OA.

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Ethical consideration
None.

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Conflict of interest

None.

Authors' contributions

MR: data curation, formal analysis, investigation, and methodology, writing, original draft. AJ: supervision, resources, and writing, original draft.

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