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A comparison of knee braces during walking for the treatment of osteoarthritis of the medial compartment of the knee

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In this cross-over study, we evaluated two types of knee brace commonly used in the conservative treatment of osteoarthritis of the medial compartment. Twelve patients confirmed radiologically as having unilateral osteoarthritis of the medial compartment (Larsen grade 2 to grade 4) were studied. Treatment with a simple hinged brace was compared with that using a valgus corrective brace. Knee kinematics, ground reaction forces, pain and function were assessed during walking and the Hospital for Special Surgery scores were also determined.

Significant improvements in pain, function, and loading and propulsive forces were seen with the valgus brace. Treatment with a simple brace showed only significant improvements in loading forces. Our findings suggest that although both braces improved confidence and function during gait, the valgus brace showed greater benefit.

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Osteoarthritis (OA) of the knee affects approximately 80% of individuals by the age of 55 years.[1] It is more prevalent in the medial compartment[2] and it is estimated that during normal gait approximately 60% to 80% of the load is transmitted through the medial side.[3] This will increase any pain and functional impairment in an osteoarthritic joint.[4]

Management of OA of the medial compartment of the knee in active individuals who are unsuitable for surgery is a challenge. High tibial osteotomy is said to contraindicate unicompartmental arthroplasty.[5] Consequently, other forms of conservative management require consideration once traditional methods such as loss of weight, active exercises and analgesia have failed.

Valgus bracing attempts to reduce excessive compartmental loading and increase function. The brace unloads the painful compartment by applying a three-point force system.[6] Increased activity and reduced pain might then delay the need for operation.[7,8]

Several studies on the use of valgus braces report that patients have considerable relief from pain, improved function,[6-10] and a reduction in loading of the medial compartment.[11] Few studies have considered whether biomechanical changes relate to these perceived benefits. Draper et al[12] analysed the effects of a valgus brace on gait symmetry, and found that gait became more symmetrical both after the initial fitting and after wearing of the brace for three months. While concluding that the brace was clinically effective, no reason was given for its success.

The efficacy of bracing has been debated because, to combat varus, there is a need for large resistive moments which would be intolerable for most patients.[13] It is possible, however, that a brace might achieve increased function and a more symmetrical gait, through either increased proprioceptive feedback or a placebo effect which gives the wearer more confidence in the stability of their limb.

We have compared the kinematic and kinetic effects of a valgus brace with those of a simple hinged brace in a cross-over design study over a period of six months.

Patients and Methods

Twelve physically active patients (seven men, five women) with a mean age of 60.2 years (50 to 75) were recruited from the general orthopaedic outpatient clinics of two hospitals. The subjects had unilateral OA of the medial compartment confirmed radiologically (Larsen grade[12] 2 to grade 4 on anteroposterior and Merchant's radiographs and Larsen grade 0 to grade 1 of the lateral compartment). The study had ethical approval and informed consent was obtained. All the patients had an abnormal varus mechanical axis (mean 6.8°; 1° to 12°). They had no significant hip, back or contralateral leg symptoms, had not undergone an arthroscopy within the preceding six months

Table I. Mean (SD) flexion/extension angle (°) of the knee on the affected side

	Condition*			One-way ANOVA† p values		
	NB	B1	B2	NB *vs* B1	NB *vs* B2	B1 *vs* B2
Knee flexion at heel-strike (°)	5.5 (9.1)	8.9 (6.0)	6.6 (6.0)	0.962	1.000	1.000
Knee flexion during loading (°)	18.7 (9.0)	22.2 (8.0)	18.0 (9.6)	1.000	1.000	0.516
Knee extension during midstance (°)	11.4 (8.3)	14.3 (7.0)	9.6 (9.0)	1.000	1.000	0.211
Knee flexion during swing (°)	60.3 (4.8)	62.9 (7.8)	54.3 (7.9)	1.000	0.105	0.048‡

* NB, no brace; B1, non-valgus bracing; B2, valgus bracing
† ANOVA, analysis of variance
‡ denotes significance

Table II. Mean ground reaction forces on the affected side (N/body weight; SD)

	Condition*			One-way ANOVA† p value		
	NB	B1	B2	NB *vs* B1	NB *vs* B2	B1 *vs* B2
Peak vertical loading force	1.047 (0.059)	1.085 (0.084)	1.120 (0.050)	0.540	0.042‡	0.676
Force at mid stance	0.862 (0.106)	0.839 (0.098)	0.895 (0.103)	1.000	1.000	0.850
Peak vertical propulsive force	1.008 (0.058)	1.096 (0.060)	1.097 (0.045)	0.047‡	0.020‡	1.000
Posterior loading force	0.110 (0.042)	0.150 (0.051)	0.153 (0.047)	0.042‡	0.048‡	1.000
Anterior propulsive force	-0.136 (0.045)	0.158 (0.064)	-0.168 (0.047)	0.881	0.343	1.000

* NB, no brace; B1, non-valgus bracing; B2, valgus bracing
† ANOVA, analysis of variance
‡ denotes significance

and were physically and mentally able to comply with the wearing of a brace.

Patients were assessed clinically using visual analogue scores[12] (VAS) for resting, standing, walking and climbing stairs and Hospital for Special Surgery[12] (HSS) activity and functional questionnaires. A decrease in VAS indicated a reduction in pain, and an increase in HSS score showing an improvement in activity and function. We have compared non-valgus (B1) and valgus (B2) bracing. Each patient was randomly allocated to either an 'off-the-shelf' hinged brace (Bilateral uniaxial hinge B1, Camp Healthcare, Sheffield, UK), or a Generation II ADJ Unloader (GII Orthotics Europe, Eindhoven, The Netherlands). The same fully-trained technician fitted both types. Each patient was instructed in the use and care of the brace and advised to wear it all day for six months. Kinematic and kinetic gait analysis and the VAS and HSS scores were then determined again. The patients immediately received the second type of brace for a further six months, after which the analyses were repeated. During the study, the patients were advised to continue to take any current medication and not to begin new treatment.

Kinematic and kinetic gait analysis. The patient was asked to wear the same comfortable shoes for each gait analysis. They walked the length of the gait laboratory at their own speed and repeated this twice. Kinematic data were collected using a six-camera Proreflex MCU240 motion analysis system (Qualisys Medical AB, Gothenburg, Sweden) at 100 Hz. Retroreflective markers were placed on the anterior superior iliac spine, the centre of the greater trochanter, the superior aspect of the patella, the lateral joint line of the knee, the tibial tuberosity, the lateral malleolus and at the base of the fifth metatarsal. The data were smoothed with a Butterworth 4th order filter with a cut-off frequency of 6 Hz. Kinetic data were collected from two Kistler force platforms (Kistler Instruments Ltd, Hampshire, UK) at 200 Hz.

From the kinematic data, the mean values were found for the key points on the flexion/extension angular velocity graphs of the knee. Kinetic data provided the peaks and troughs of the vertical and anteroposterior ground reaction forces.

Statistical analysis. One-way analysis of variance (ANOVA) tests were performed with *post hoc* pairwise comparison for the kinematic and kinetic variables. P values compared the results of wearing both braces after six months with those before bracing. They also compared the effect of the two braces. Tests were performed for both the affected and unaffected sides. A level of significance was set at the 5% level for each test with a Bonferroni adjustment to reduce the chance of type-1 errors.

Results

Knee angle. The flexion pattern of the knee on the affected side showed a significant reduction of flexion during the swing phase with bracing (Table I).

Knee angular velocity. The pattern of angular velocity of the knee showed no significant differences between the three conditions on the affected and unaffected sides.

Ground reaction forces. The ground reaction forces on the affected side showed a significant increase during loading and push-off (Table II).

VAS and HSS scores. Details are given in Tables III and IV.

At the initial assessment the mean modified HSS score was 49.3 (37 to 62; Table IV). After wearing the B2 brace for six months this had increased to 65.7 (42 to 92;

Table III. Visual analogue score for the activities during each condition for the initial assessment (no brace) and that at six months

Condition*	Rest	Walking	Standing	Stairs
NB	4.9	8.0	6.0	8.5
B1	3.6	7.4	6.3	7.9
B2	2.9†	5.4†	4.8	5.9†

* NB, no brace; B1, non-valgus bracing; B2, valgus bracing
† denotes significance

Table IV. Hospital for Special Surgery scores during each condition for the initial assessment (no brace) and that at six months

Condition*	HSS score
NB	49.3
B1	53.5
B2	65.7†

* NB, no brace; B1, non-valgus bracing; B2, valgus bracing
† denotes significance

$p < 0.002$). Wearing of the simple hinged brace gave a slight increase in the HSS score to 53.5 (31 to 84), but this was not statistically significant.

All patients initially reported moderate to severe pain on walking and using stairs with a mean of 8.0 and 8.5, respectively (Table III). The mean scores for resting and standing were less at 4.9 and 6.0, respectively. All patients reported subjectively less pain on walking, independent of the brace used.

Discussion

Most previous studies of valgus bracing have concentrated on the clinical effects of one or more types of brace. Kinetic data showed that the B2 brace produced significantly greater loading forces in the vertical and posterior directions, and a significant increase in the propulsive vertical forces. Improvements in the anterior propulsive force were observed, but were not significant. These data reflect improved confidence during loading and an ability to push-off vertically. The B1 brace showed improvement in vertical and posterior loading but not to the same extent. No improvement in propulsion was seen with the B1 brace. Both showed a trend towards a more normal gait pattern and clinically better function. Significant improvement in the HSS score was seen only with the B2 brace.

The increase in the loading forces may not be viewed as positive since this could suggest that there was more load on the medial compartment. However, the VAS results showed significant reduction in pain while resting, walking and stair-climbing with the B2 brace. This indicates that the increased load is not causing pain but is reduced by support from the brace. This view is supported by Kirkley et al[10] and Lindenfeld et al.[7]

The B1 brace gave increased loading forces, but no significant reduction in pain. The implication is that the simple hinged brace has an improved effect on confidence in loading without increasing pain. This complies with the theoretical action of such a brace to be supportive, but not as supportive in the coronal plane as a valgus brace. The differences between the B1 and B2 braces suggest that the benefits of the latter are not just confidence or placebo effects.

The valgus brace had a functional drawback. It caused significant reduction of flexion during the swing phase. This restriction can result in reduced foot clearance and a shorter stride. The simple hinged brace had no such restriction. Possible causes of restriction are that the valgus brace is significantly larger and, with only a single hinge, is prone to torsional misalignment.

Patient compliance was not recorded, but since most patients had benefit from both braces, we believe that compliance was high. Some patients reported that the valgus brace was bulky, but continued to wear it for the specified six months.

It could be argued that over the study period, deterioration in OA would be seen. However, there was no such deterioration.

Our study supports the use of valgus knee braces as an alternative treatment option for carfully selected patients with OA of the medial compartment. Further work is required to analyse the restriction of movement produced by the brace during the swing phase and whether different designs of brace could improve on this.

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