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EFFECTS OF COMBINED CUSTOM VALGUS KNEE BRACE AND CUSTOM LATERAL WEDGE FOOT ORTHOTIC USE DURING STAIR ASCENT

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Purpose: The effects of valgus knee braces and lateral wedge foot orthotics in patients with medial compartment knee osteoarthritis (OA) have been extensively studied during level walking; however, the biomechanical and clinical findings have been inconsistent. It remains unclear whether the observed small-to-moderate effect sizes carry over to more demanding tasks that place greater loads on the medial compartment of the knee. Few previously published studies have examined the effects of valgus braces and lateral wedge orthotics during stair climbing. The purpose of the present study was to compare the biomechanical effects of a custom valgus knee brace and custom lateral wedge foot orthotic, used separately and combined, during stair ascent in patients with medial compartment knee OA.

Methods: All patients were custom-fit with a valgus knee brace and a full-length custom-made lateral wedge foot orthotic prior to testing. Both devices were fit to achieve maximum relief of symptoms while maintaining patient comfort. Patients underwent three-dimensional kinematic and kinetic gait analysis during stair ascent with a 10-camera motion capture system, modified Helen Hayes marker set and synchronized force plate embedded in the stairs. Using a step through pattern, all patients ascended five stairs under four randomized conditions: (1) neither knee brace nor foot orthotic, (2) knee brace only, (3) foot orthotic only, and (4) knee brace and foot orthotic. Pain was assessed after each condition using a numeric rating scale (0-10). Sagittal and frontal plane knee kinematic and kinetic gait variables during the stance phase of stair ascent were compared between conditions using repeated measures analysis of variance. Additional outcomes were measured to explore potential gait compensation mechanisms.

Results: 35 patients (22 males, 13 females) were recruited and enrolled in the study. Kinematic and kinetic gait data are presented in Table I. The largest decrease in the external knee adduction moment occurred when patients wore both the valgus knee brace and lateral wedge foot orthotic compared to the control condition, although this difference was not statistically significant in either the early ($p = 0.76$) or late ($p = 0.74$) stance phase. The maximum knee adduction angle significantly decreased ($p<0.001$) from the control condition during both brace conditions. In the sagittal plane, the knee flexion moment significantly increased during all intervention conditions ($p<0.05$) compared to the control, with the largest increase occurring when both brace and orthotic were worn together ($p<0.001$). No significant changes were observed between conditions for the knee flexion ($p = 0.39$) or extension ($p = 0.06$) angle, or knee extension moment ($p = 0.57$). Toe-out and lateral trunk lean, were significantly less during both conditions when the lateral wedge orthotic was worn ($p<0.001$), and the vertical ground reaction force (GRF) was significantly greater during both conditions when the valgus knee brace was worn ($p<0.001$). Patients reported significantly less pain after each intervention condition compared to the control ($p = 0.001$).

Conclusions: Results from the present study suggest that although the combined use of a custom valgus knee brace and custom lateral wedge foot orthotic significantly altered select gait biomechanics and pain during stair ascent, it did not reduce the external knee adduction moment.

Table I
Means (SD) for knee kinematic and kinetic gait variables during stair ascent

	Control	Orthotic	Brace	Combined
1st Pk KAM (%BWxHT)	2.47 (1.12)	2.46 (0.97)	2.40 (0.91)	2.40 (0.95)
2nd Pk KAM (%BWxHT)	2.53 (1.03)	2.52 (1.03)	2.49 (1.02)	2.45 (0.99)
Knee adduction angle (°)	17.75 (6.64)	17.29 (7.54)	15.57 (6.35)*	15.83 (6.84)*
Knee flexion moment (%BWxHT)	3.11 (1.16)	3.42 (1.26)*	3.38 (1.33)*	3.65 (1.35)*
Knee extension moment (%BWxHT)	-2.58 (1.10)	-2.51 (1.06)	-2.63 (1.12)	-2.55 (1.00)
Knee flexion angle (°)	62.54 (10.34)	62.26 (10.30)	62.86 (11.22)	63.51 (10.80)
Knee extension angle (°)	2.95 (7.42)	3.17 (7.77)	4.34 (7.98)	4.00 (7.80)
Vertical GRF (Nm/kg)	10.36 (0.77)	10.32 (0.74)	10.58 (0.87)*	10.48 (0.78)*
Trunk lean (°)	5.22 (3.26)	4.35 (2.84)*	5.42 (3.52)	4.79 (3.36)*
Toe out (°)	14.98 (6.54)	10.71 (5.65)*	15.20 (6.24)	10.98 (5.49)*
Gait speed (m/s)	0.58 (0.10)	0.60 (0.11)	0.59 (0.11)	0.59 (0.12)
Pain (0-10)	3.06 (2.00)	2.43 (2.16)*	2.43 (2.23)*	2.34 (2.03)*

*$p<0.05$;
KAM = Knee Adduction Moment; BW = Body Weight; HT = Height; GRF = Ground Reaction Force.

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GAIT BIOMECHANICS PRE AND POST COMBINED HIGH TIBIAL OSTEOTOMY AND ACL RECONSTRUCTION

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Purpose: Simultaneous anterior cruciate ligament (ACL) reconstruction and high tibial osteotomy (HTO) is a combined surgical procedure intended to improve kinematics and kinetics in the unstable knee with varus alignment and medial compartment knee OA. The primary objective of this study was to compare three-dimensional (3D) gait biomechanics between limbs before and after unilateral, simultaneous ACL reconstruction and medial opening wedge HTO. Secondary objectives were to compare radiographic alignment (mechanical axis angle, MAA) and Knee Osteoarthritis Outcome Scores (KOOS) before and after surgery.

Methods: Thirty-four patients (39 ± 9 years) with varus alignment (MAA = −5.6 ± 3.2°), medial compartment knee OA and ACL deficiency completed 3D gait analysis, full-limb standing anteroposterior radiographs and the KOOS preoperatively, 2 and 5 years postoperatively.

Results: Analysis of variance indicated a significant time (pre, 2yr, 5yr) by limb (surgical, non-surgical) interaction for the peak external knee adduction, flexion, extension, internal and external rotation moments during the stance phase of walking. In the surgical limb, there were significant changes in the peak knee adduction moment from preoperative to 2 years postoperative, and in the peak knee flexion moment from preoperative to 5-years postoperative. The overall mean changes (95%CI) from preoperative to 5 years postoperative were as follows: −1.55%BW*Ht (−1.86, −1.26) for the peak knee adduction moment, −0.66%BW*Ht (−0.16, −1.17) for the peak knee flexion moment, 0.36% BW*Ht (−0.08, 0.79) for the peak knee extension moment, −0.54% BW*Ht (−0.66, −0.43) for the peak internal rotation moment and 0.011% BW*Ht (0.033, −0.010) for the peak external rotation moment. There was a small, statistically significant increase in the peak knee adduction moment of the non-surgical limb [0.34%BW*Ht (0.15, 0.53)]. The MAA in the surgical limb was altered by 7.1o (5.5o, 8.8o). There was no change in alignment of the non-surgical limb [−0.2o (0.7, −1.1)]. Overall, mean increases in the KOOS from preoperative to 5 years postoperative were as follows: Pain: 12.4 (2.2, 22.7), Function during ADL: 9.9 (−0.8, 20.7), Function during Sports: 17.3 (0.32, 34.2), Symptoms: −2.7 (−12.7, 7.4) and Quality of Life: 32.8 (17.9, 47.6).

Conclusions: Combined ACL reconstruction and medial opening wedge HTO results in long-term (5 year) changes in the external moments about the knee in all three planes during walking. Future work is required to evaluate whether these changes in gait biomechanics are related to clinical outcomes following this combined procedure.