EFFECT OF CUSTOM MADE KNEE BRACE WITH 3D HINGES

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INTRODUCTION

The external joints built into knee braces are designed to be reasonably compatible with joint motion, but the main purposes of the braces themselves are to provide stability or to restrict the motion. There are several advantages to accurate reproduction of knee motion in an external joint assembly such as a knee brace, including reduction of pistoning forces, better ligament protection and kinematic compatibility (Walker, 1985).

The study of geometry and kinematics of the normal human knee can provide results applied to external joint design of knee orthoses (Walker, 1985). As such, some studies aimed at determining the congruence of the instantaneous anatomical knee joint axis and a knee orthosis joint axis (Niesche, 2008).

The objective of this study was to evaluate the effect of a custom made knee brace, in which hinges reproducing the three-dimensional motion of the tibio-femoral joint in 6 degrees of freedom is built, on three dimensional kinematics and kinetics characteristics of the lower extremity during normal walking in osteoarthritic patients.

METHOD

Comparison of gait biomechanics of patients with knee osteoarthritis (OA)

Population:
- n=17 (7 men and 10 women)
- 19 legs total (1 male and 1 female subjects had knee braces for both inferior limbs)
- Age: 60 ± 15 years
- Weight: 82 ± 19 kg
- Knee OA preponderant at the medial compartment
- Kellegren-Laurence grade varying between 2 and 3

Gait analysis:
- With/without the use of a custom made Evoke knee orthosis:
- 10 normal gait trial with orthosis and 10 normal gait trial without orthosis
- All subjects completed an adaptation period between the delivery of the orthosis and the experiment

Kinematics:
- VICON motion capture system (Oxford, UK) with 18 cameras (100 Hz)
- Markers (23): pelvis (4), thigh (7), leg (7) and foot (5)
- Parameters: 3D angles (°) at the hip, knee and ankle

Kinetics:
- Gait path of 8 meters with an AMTI force-plate (Watertown, USA) (1000 Hz) located at the center
- Parameters: 3D moments (Nm) at the hip, knee and ankle

EMG:
- DELSYS Wireless EMG (Natick, USA)
- Parameters: EMG (V) for 4 muscles (vastus lateralis, hamstring, gastrocnemius, peroneus longus)

Statistical analysis:
- Comparisons of gait trial with vs without orthosis
- SPM (Statistical Parametric Mapping)
- Paired measurements (1st trial vs 1st trial, 2nd trial vs 2nd trial… 10th trial vs 10th trial)
- Bonferroni corrections applied to counteract multiple comparisons ($p < 0.05$)

RESULT

↑ Walking speed (0.02 m/s or yards/second) with orthosis

ABDUCTION/ADDUCTION:
↓ Adduction angle at the hip with orthosis (60% of gait cycle)

FLEXION/EXTENSION:
↑ Flexion angle at the knee with orthosis (2°) (15-65% of gait cycle)

EXTERNAL/INTERNAL ROTATION:
↑ External rotation angle of the leg vs thigh with orthosis (50% of gait cycle)
↑ External rotation moment of the foot vs leg with orthosis (0-10% of gait cycle)

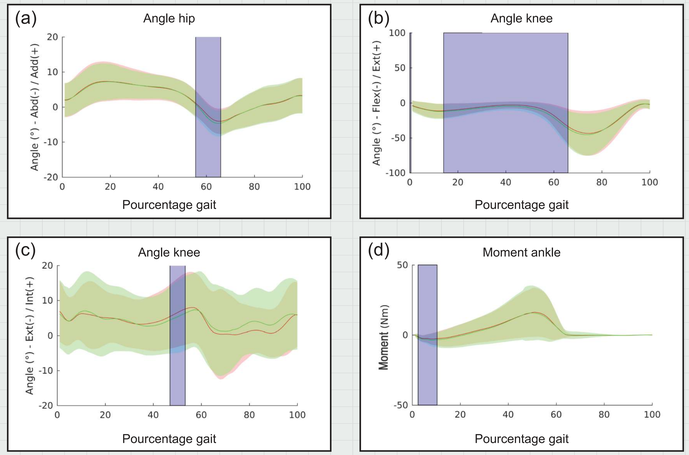

Figure 1
(a) Abduction/adduction angle at the hip, (b) Flexion/extension angle at the knee, (c) External/internal rotation at the knee, (d) Moment at the ankle.

DISCUSSION

The results show that the use of the knee orthosis can benefit lower limb motion as indicated by an increase in walking speed. The decrease in adduction angle at the hip could lead to a decrease in medial shift of the femur on the tibial plateau and limit the load at the medial knee compartment during the end of contact phase (Zeighami et al., accepted). The increase of knee flexion can indicate a higher range of motion at the knee joint. The increase in external rotation angle of the leg in reference to the thigh could show a preparation to the push-off phase. The increase in external rotation moment of the foot in reference to the leg could demonstrate an absorption of the load following heel strike.

CONCLUSION

This study brought forward evidence that the use of a custom made knee orthosis designed with hinges reproducing the three-dimensional motion of the tibio-femoral joint can affect motion at the inferior limb during normal gait of OA patients.

CLINICAL APPLICATIONS

This study provided data on the effect of a knee brace comprising a novel hinge design reproducing three-dimensional motion of the tibio-femoral joint.

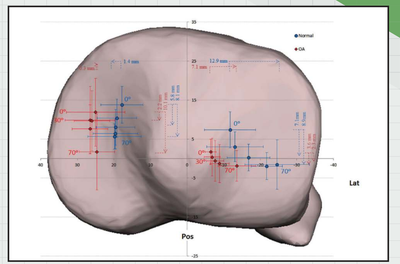

Figure 2
Zeighami et al., In Press. Average contact point trajectories in 10 healthy (blue) and 9 OA (red) subjects during squat, normalized over a tibial plateau.

REFERENCES

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