Femoral Rollback During Walking Is A Myth

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Introduction: Knee motion has been studied for many years using various measurement tools, such as externally applied devices, intracortical devices, x-rays and MRIs. The consensus in the literature from the 1970s and 1980s was that as knee flexion increased, there was a coupled "femoral rollback" phenomenon. This concept of "femoral rollback" has been written in numerous textbooks and journal publications over the years, and many orthopaedic devices (braces and total knee prosthesis) have been designed based on this principle. In the 1990's and more recently in 2002, new evidence arose which demonstrated that this concept was incorrect (1,3). The purpose of this study was to measure knee motion dynamically during level walking in normal subjects and test the hypothesis that femoral rollback does not occur during the swing flexion stages of walking, and in fact the exact opposite occurs (tibial rollback).

Statement of Clinical Significance: Greater understanding of the dynamic kinematics of the knee joint would ultimately lead to better design of orthopaedic devices such as knee prostheses and braces, and help improve treatments for knee joint pathologies.

Methodology: Eighteen healthy subjects (7 males and 11 females), with no known lower-limb pathologies were studied. The subjects ranged in age from 21 to 50 years (mean 29 yrs). Each subject read and signed an informed consent prior to participating in this study. On the day of testing, each subject was attached with an Instrumented Spatial Linkage Device (ISLD). The ISLD has five rotary potentiometers and one linear potentiometer mounted in a 7075 T6 aluminum frame that weighs approximately 0.15 kg.

The ends of the device are flat with rectangular 6061 T6 aluminum plates or "arms" that slide into rails mounted onto leg cuffs made of a flexible aluminum material. The ISLD arms secure to the rails with small set-screws that inhibited movement of the arms inside the rails. The leg cuffs are designed by a brace manufacturer (Bledsoe Brace Systems, Grand Prairie, Texas) and they provide a comfortable and stable attachment to the leg (Figure 1). They mold around the bony protuberances of the leg and are anchored by muscle bulges such as the gastrocnemius muscle in the shank to prevent slippage. The cuffs adhere to Coban® tape that is strapped around the skin of the thigh and shank and secure circumferentially around each leg segment with two Velcro® straps so that excess motion between the cuffs and the skin is reduced. Each ISLD requires four leg cuffs: a thigh cuff and a shank cuff for each leg. The cuff attachments do not restrict knee motion and thus allow full range of motion. The ISLD is connected to a 12-bit DATAQ A/D converter via an umbilical cord. A software program was written in Labview 5.0 development environment in order to access the 12-bit analog-to-digital converter board mounted inside a desktop computer. Knee joint coordinate system transformations were determined using the Grood and Suntay method (2). The ISLD is capable of recording joint motion that is accurate

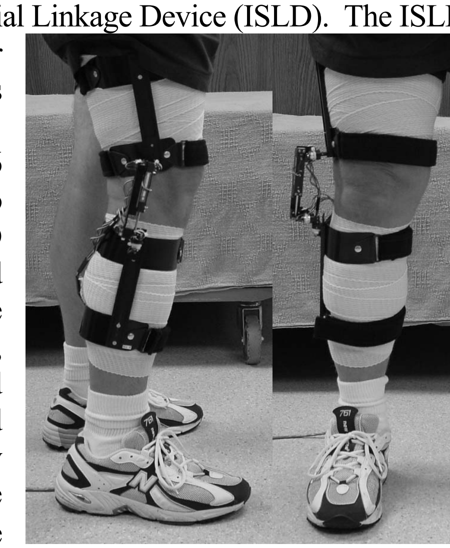

Figure 1

to within ±0.8 mm in translation and ±1.4 degrees in rotation without taking into account the effects of extraneous skin motion due to soft tissues. Once the ISLD was attached to each subject, that subject was asked to walk down a level walkway, up and down a flight of stairs and on a treadmill set at a decline of 10 degrees. Only the results for the level walking will be shown for the purposes of this abstract.

Results: Figures 2A and 2B show the average and one standard deviation of the flexion/extension and anterior/posterior tibial translation curves. The flexion/extension curve is normal with its typical bi-phasic pattern. The anterior/posterior tibial translation curve shows some very interesting patterns which is contradictory to the "femoral rollback" phenomenon. The tibia just prior to heel strike is anteriorly positioned with respect to the femur. This anterior position of the tibia is reduced back into neutral during stance phase, and then as the knee moved into flexion, the tibia translates posteriorly.

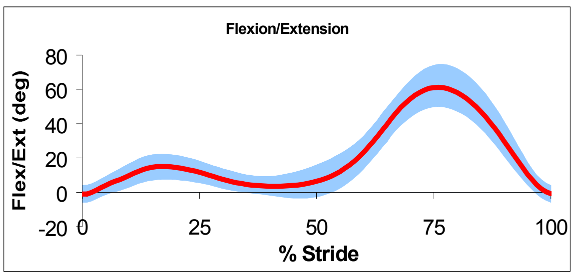

Figure 2A

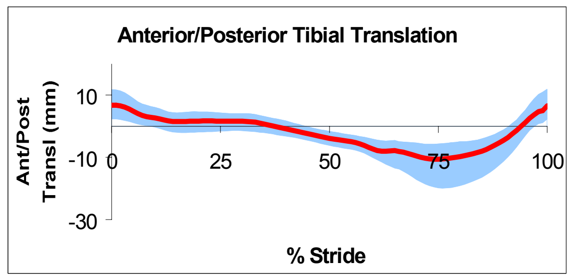

Figure 2B

These dynamic knee motions are the exact opposite of many published studies, but those studies were either non-weight bearing, static or both (4-6). Our results are very similar to the few previously published studies which record dynamic knee motion (1-3). Lafortune used intracortical pins and a reflective motion capture system and Andriacchi used a unique "point cluster" technique with a reflective motion capture system. Both these researchers found that during walking, the tibia shifted posteriorly during the swing phase flexion portion of the gait cycle, which is contradictory to the "femoral rollback" phenomenon.

Discussion: The phenomenon of "Femoral Rollback" does not seem to hold when it comes to dynamic knee motion. Researchers in the past have assumed that static and/or non-weight bearing knee motion is similar to that during dynamic motion such as walking. We have shown that not to be the case with our dynamic knee measurement tool and as technology improves which allows for more accurate 6-degree-of-freedom dynamic knee motion analysis, the "femoral rollback" thinking should become a thing of the past. We believe that this posterior tibial translation occurs during knee flexion as a result of muscular and ligamentous dynamics. This information could play a part in the redesign of such orthopaedic devices as knee braces and total knee prosthesis, which have been based on incorrect assumptions and information.

References:

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Acknowledgements: We would like to acknowledge the assistance of Bledsoe Brace System.