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Technical note

Measurement of the screw-home motion of the knee is sensitive to errors in axis alignment

Stephen J. Piazza[a,b,c,*], Peter R. Cavanagh[a,b,d,e,f]

[a]*Center for Locomotion Studies, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802 and Hershey, PA 17033, USA*
[b]*Department of Kinesiology, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802 and Hershey PA 17033, USA*
[c]*Department of Mechanical & Nuclear Engineering, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802 and Hershey PA 17033, USA*
[d]*Department of Biobehavioral Health, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802 and Hershey PA 17033, USA*
[e]*Department of Medicine, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802 and Hershey PA 17033, USA*
[f]*Department of Orthopaedics and Rehabilitation, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802 and Hershey PA, 17033, USA*

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Abstract

Measurements of joint angles during motion analysis are subject to error caused by kinematic crosstalk, that is, one joint rotation (e.g., flexion) being interpreted as another (e.g., abduction). Kinematic crosstalk results from the chosen joint coordinate system being misaligned with the axes about which rotations are assumed to occur. The aim of this paper is to demonstrate that measurement of the so- called "screw-home" motion of the human knee, in which axial rotation and extension are coupled, is especially prone to errors due to crosstalk. The motions of two different two-segment mechanical linkages were examined to study the effects of crosstalk. The segments of the first linkage (NSH) were connected by a revolute joint, but the second linkage (SH) incorporated gearing that caused 15° of screw-home rotation to occur with 90° knee flexion. It was found that rotating the flexion axis (inducing crosstalk) could make linkage NSH appear to exhibit a screw-home motion and that a different rotation of the flexion axis could make linkage SH apparently exhibit pure flexion. These findings suggest that the measurement of screw-home rotation may be strongly influenced by errors in the location of the flexion axis. The magnitudes of these displacements of the flexion axis were consistent with the inter-observer variability seen when five experienced observers defined the flexion axis by palpating the medial and lateral femoral epicondyles. Care should be taken when interpreting small internal–external rotations and abduction–adduction angles to ensure that they are not the products of kinematic crosstalk. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Screw-home; Knee kinematics; Motion analysis; Flexion axis; Kinematic crossstalk

1. Introduction

External rotation of the tibia with respect to the femur that accompanies knee extension is commonly thought to occur in the normal knee. This motion, the so-called "screw-home" mechanism, is described as being generated by asymmetry between the femoral condyles. The medial condyle has been reported to be approximately 1.7 cm longer than its lateral counterpart (Nordin and Frankel, 1980) and external tibial rotation is presumed to result from the tibia conforming to the femoral condyles as the knee extends. Screw home has been described as characteristic of healthy knee motion and its absence is often described as indicative of instability or joint damage such as meniscal tears (Nordin and Frankel, 1980; Tasker and Waugh, 1982; Turek, 1984). The perceived clinical importance of screw-home motion was underscored by Helfet (1974), who devised a test for its absence in patients, and by several investigators who have measured total knee replacement motions to determine whether normal screw-home motion was present (Stein et al., 1988; Nilsson et al., 1990; Kärrholm et al., 1994; Dennis et al., 1998).

Several authors have measured the transverse-plane rotations of the normal knee with varying results. Levens

* Correspondence address. Center for Locomotion Studies, Pennsylvania State University, 29 Recreation Building, University Park, PA 16802, USA. Tel.: + 1-814-865-3413; fax: + 1-814-863-4755.
E-mail address: sjp12@psu.edu (S.J. Piazza).

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landmarks whose locations may be difficult to determine with sufficient accuracy. Until such a system is developed, small out-of-plane rotations that are measured along with large flexion angles should be regarded as suspect. Such rotations should be examined carefully to ensure that they are not the product of kinematic cross-talk before they are used as the basis for treatment decisions.

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