EFFECTS OF KNEELING ON TIBIOFEMORAL BIOMECHANICS IN THE NATIVE KNEE

Jason K. Hofer1, Ryuichi Gejo1,2, Michelle H. McGarry1, Thay Q. Lee1
1Orthopaedic Biomechanics Laboratory, Long Beach VA Healthcare System and University of California, Irvine, Long Beach, CA; 2Orthopaedic Surgery, University of Toyama, Toyama, Japan
tqlee@med.va.gov

Introduction: Kneeling is an activity that is required by individuals for many occupations, hobbies, and recreational activities. The hypothesis of this study was that deep knee flexion and kneeling has a strong influence on the biomechanics of the tibiofemoral joint. The objective of this study was to quantify the tibiofemoral joint contact areas, pressures, and kinematics in response to kneeling in native cadaveric knees.

Materials and Methods: Five cadaveric knees (3 Male, 2 Female) average age 84.2 years old (range 78-93) were dissected of all skin and subcutaneous tissue, leaving the extensor mechanism, hamstrings, joint capsule, ligaments, and retinaculum intact. The specimens were securely mounted in a custom knee testing jig that permits physiologic muscle loading and the application of an anteriorly directed force to simulate kneeling (Fig 1a). The femoral epicondylar axis was aligned parallel to the coronal plane of the jig. This testing setup provided independent control of six degrees of freedom at the femur and five degrees of freedom at the tibia. The femur was locked in place during testing. Five degrees of freedom was maintained for the tibia. Anatomically based multi-plane loading of the quadriceps mechanism (vastus medialis 51N, rectus femoris/vastus intermedius 87N, vastus lateralis 77N) and hamstrings (biceps femoris 31N, semimembranosus/semitendinosus 54N) was used to simulate physiologic loading of the knee joint. The total anterior load was 300N. The knees were tested under three different loading conditions at flexion angles of 90, 105, 120, and 135°. The three loading conditions were as follows: No anterior loading to simulate a crouching position, 339N of anterior force to simulate double stance kneeling, corresponding to 50% mean body weight (MBW) of a 70kg person; 668N applied to the anterior knee to simulate single stance kneeling, corresponding to 100% MBW of a 70kg person. The anterior load was applied at a 90° angle to the tibial axis with a load plate attached to a uniaxial load cell (Omega Inc, Stamford, CT). Tibiofemoral joint kinematics were determined by digitizing three points on the distal femur and three points on the proximal tibia using a Microscribe 3DLX (Immersion Corp, San Jose, CA). The distal femur points were on the lateral femoral epicondyle, the medial femoral epicondylar sulcus, and the posterior femur 6cm superior to tibiofemoral joint line. The proximal tibia points were on Gerdy’s tubercle laterally, a point 3cm inferior to the medial joint line and centered in the anterior-posterior tibial plane, and the posterior tibia 6 cm inferior to tibiofemoral joint line. Tibiofemoral joint contact characteristics were measured using Tekscan (Tekscan Inc, South Boston, MA). The Tekscan sensors were inserted through the posterior capsule, taking care to preserve the menisci, collateral ligaments, and cruciate ligaments. Tibiofemoral joint contact areas, contact pressures, and peak contact pressures were obtained for the medial and lateral joint compartments (Fig 1b).

Results: The average posterior tibial translation in response to kneeling is shown in Figure 2a. With the addition of the second 339N, moving from double stance to single stance kneeling, posterior tibial translation was significantly smaller at all flexion angles (p<0.005). Kneeling resulted in external rotation of the tibia at all flexion angles (Fig 2b). With the addition of the second 339N, moving from double stance to single stance kneeling, average tibial rotation was significantly smaller at all flexion angles (p<0.04).

Discussion: Kneeling resulted in tibial posterior translation and external rotation at all flexion angles. It also significantly increased contact area across all flexion angles, with the exception of double stance kneeling at 135° in the medial compartment. Increased total contact pressure and peak pressure was observed with double stance and single stance kneeling. There was a significantly smaller effect on tibiofemoral kinematics and contact areas in moving from double stance kneeling to single stance kneeling.

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