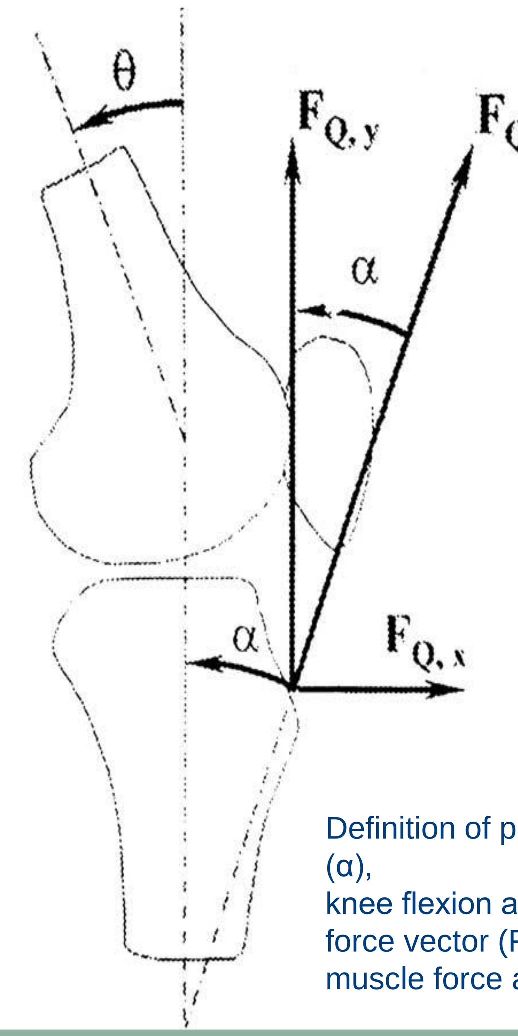
Aggressive Quadriceps Loading Can Induce Anterior Cruciate Ligament Injury

Gene DeMorat, MD, Paul Weinhold, PhD, Troy Blackburn, MS,
William Garrett, MD, PhD, and **Steven Chudik, MD**
OTRF, University of North Carolina Orthopaedics, Hinsdale Orthopaedics

Introduction

The force responsible for noncontact anterior cruciate ligament (ACL) injuries remains controversial. Published results show that 70% to 80% of ACL injuries occur via an indirect force and are classified as noncontact injuries . Although extrinsic forces involved in noncontact ACL injury are well defined, the role and source of an intrinsic force remains controversial. The patella tendon to tibial shaft angle causes an anterior tibial shear force with quadriceps activation. We hypothesize that given the proper circumstances, an intrinsic force generated by a physiologic quadriceps contraction, with the knee in slight flexion, can cause significant anterior tibial displacement and injure the ACL.



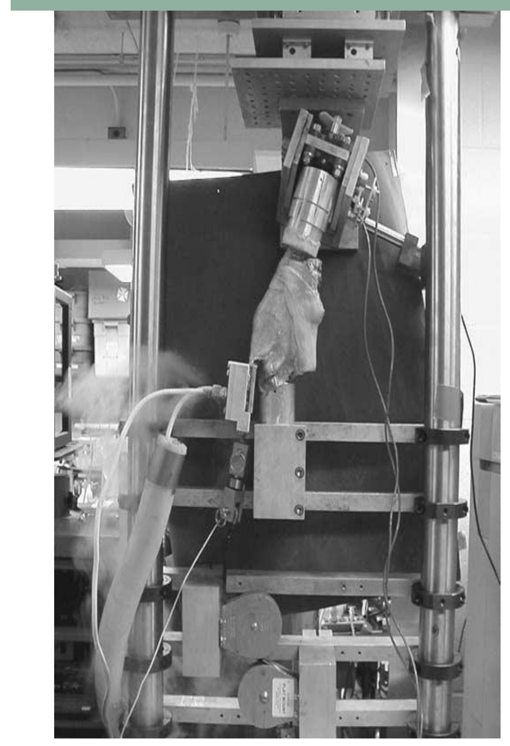
Definition of patella tendon tibial shaft angle (α),
knee flexion angle (θ), and the anterior shear force vector (FQ,X). FQ is the total quadriceps muscle force applied to the patella tendon.

Objectives

The objectives of this study were:

1. evaluate changes in anterior laxity of the knee after aggressive quadriceps loading simulating a noncontact ACL injury;
2. evaluate knee kinematics associated with aggressive quadriceps loading and relate these to clinical observation of injuries; and
3. evaluate knee structures for visual evidence of injury after aggressive quadriceps loading an relate these to clinical findings.

Methods



Testing Jig

The authors characterized noncontact ACL injury and kinematics with aggressive quadriceps loading. Thirteen fresh frozen cadaveric knees, age range 49 to 93 were tested. There were no preexisting ligamentous injuries found. The knees were held in a jig held in 20˚ of flexion while a 4500N quadriceps contraction was simulated. Knee kinematics were recorded. A KT-1000 arthrometer and a simulated active quadriceps test assessed anterior displacement, pre and post 4500N quadriceps loading. After all loading and KT-1000 measurements were completed, a formal dissection was performed of the ACL with specific attention to its tibial and femoral insertion sites. In addition, the knees were examined to determine any associated ligamentous or meniscal damage.

Results

Kinematics revealed the following mean values: anterior displacement, 19.5 mm; valgus, 2.3˚ ; and internal rotation, 5.5˚ . Mean KT-1000 and active quadriceps test differences were 4.0 mm and 2.7 mm, respectively (statistically significant P =.002 and P = .002). Six knees showed gross ACL injury at the femoral insertion. Based on ACL injury, KT-1000 differences were statistically significant (P = .029).

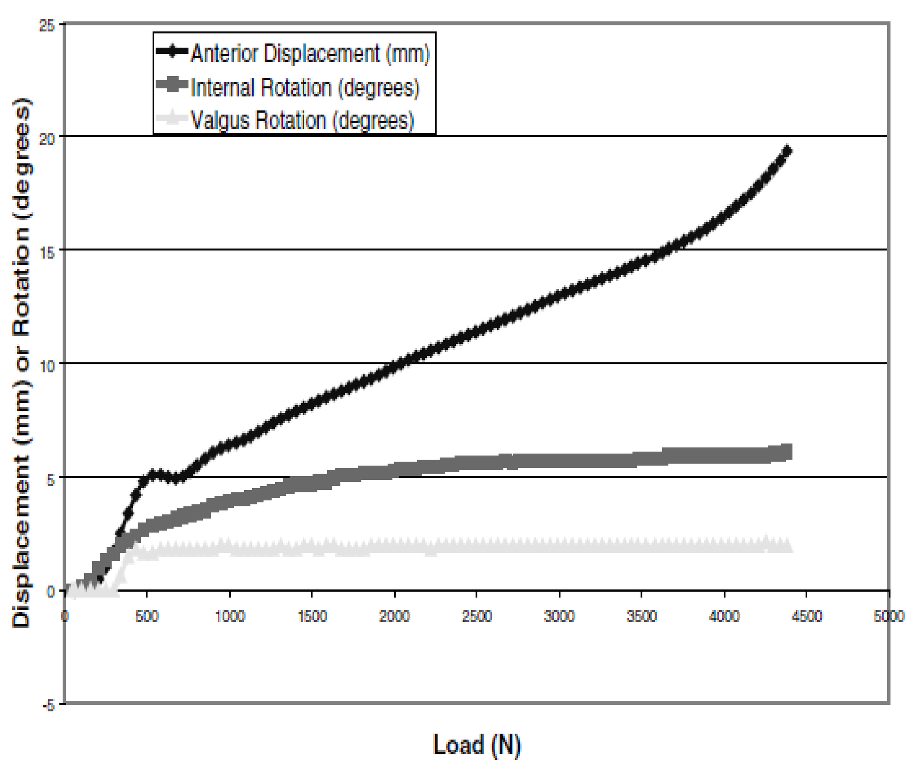


Figure 3. Kinematic data obtained from one specimen that sustained a complete ACL injury.

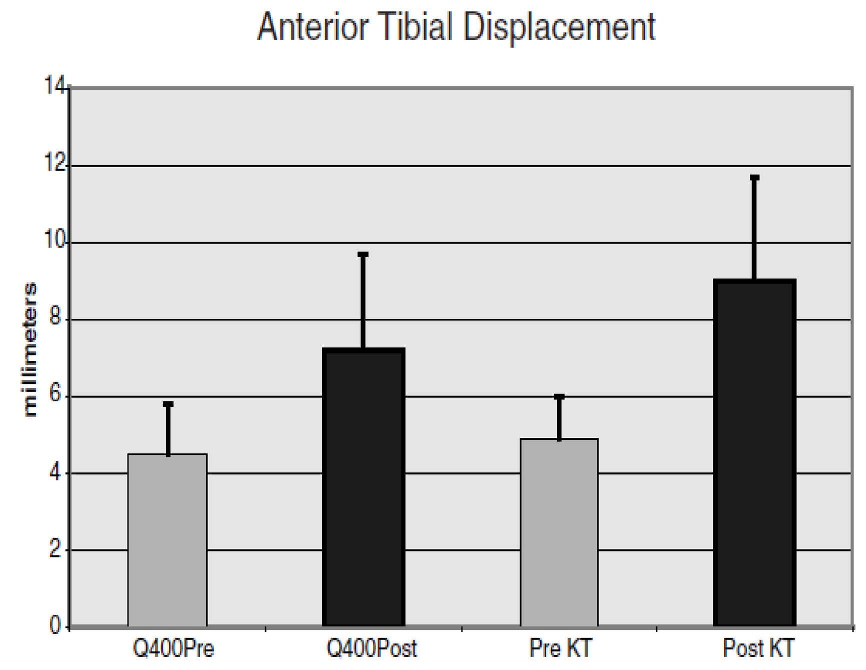


Figure 4. Anterior tibial displacement for 400 N active quadriceps (Q400) and 20-pound KT-1000 (KT) testing, pre and post 4500 N quadriceps loading.

TABLE 1
Mean 4500 N Kinematic Data for All Knees
Based on ACL Injury Status

Gross ACL status	Number of specimens	Anterior displacement (mm)	Valgus	Internal rotation
Complete injury	3	20.60	1.7°	7.4°
Partial injury	3	19.95	3.1°	5.3°
No gross injury	5	18.30	2.0°	3.9°

Conclusion

Aggressive quadriceps loading, with the knee in slight flexion, produces significant anterior tibial translation and ACL injury. This suggests that the quadriceps is the intrinsic force in noncontact ACL injuries, producing a model for further investigation.

ORTHOPAEDIC SURGERY AND SPORTS MEDICINE
TEACHING AND RESEARCH FOUNDATION

UNC ORTHOPAEDICS

Hinsdale Orthopaedics