

# CONDYLAR LIFT-OFF DOES NOT OCCUR DURING THE DEEP SQUAT

Dyrby, C O<sup>1,2</sup>; D'Lima, D D<sup>3</sup>; Colwell, C W<sup>3</sup>; Andriacchi, T P<sup>1,2</sup>

<sup>1</sup> Stanford University, Stanford, CA, USA

<sup>2</sup> VA Palo Alto Health Care System, Palo Alto, CA, USA

<sup>3</sup> Shiley Center for Orthopaedic Research & Education, Scripps Clinic, La Jolla, CA

E-mail: dyrby@stanford.edu Web: biomotion.stanford.edu

## INTRODUCTION

A number of single plane fluoroscopic image studies have shown the possibility of condyle lift off during a squat or deep knee bend (Stiehl 1995, Dennis 1998, Insall 2002, Bertin 2002). Lift-off has also been implicated in tibial component wear that can lead to polyethylene failure (Bertin 2002). These studies did not have a way to measure the forces present in the knee during the activities. Retrieval studies (Wimmer et al 1998) of polyethylene components do not show damage patterns that would suggest lift off of one compartment with high loads passing through a single compartment. In addition, the forces and moments at the knee during the deep squat are not conducive to allowing lift-off (Dyrby and Andriacchi 2000, Nagura 2002).

The purpose of this study was to quantify the forces in the medial and lateral compartment of the knee in a subject that has had an instrumented knee prosthesis during the deep squat. The hypothesis tested is that the forces measured at 30°, 60°, 90° and maximum knee flexion, in the medial or lateral compartment will not reduce to zero during the descending phase of the squat. This would indicate that both compartments remain in contact.

## METHODS

A standard Sigma PFC (DePuy J&J) with a standard primary cruciate retaining posterior

lipped prosthesis was implanted in the right knee of an 81-yr-old male (170 cm, 633 N). The upper tibial tray and locking mechanism was the same design as a primary PFC tibial component. The lower part of the tray and the stem was designed to hold custom designed load cells and telemetry system (D'Lima 2005). IRB-approved informed consent was obtained. The instrumented knee transmitted the compressive load in the medial anterior and posterior, lateral anterior and posterior compartments of the knee using four uniaxial load cells embedded in the tibial component at a rate of approximately 70Hz. These transmitted forces were recorded on a laptop computer using custom acquisition software (Labview). The sum of the two measurements in the medial and lateral compartments was used to estimate total medial compartment compressive loading. Compressive loading was normalized to body weight. The subject performed two trials of a deep squat to maximum knee flexion.

Kinematic and kinetic data during the squat were also collected using an optoelectronic system and force plate. An on/off synchronization signal was also collected in order to synch the two systems. Intersegmental moments were calculated using a previously-described 6-marker link method (Andriacchi TP et al. 2004). Data were sampled at 30°, 60°, 90° and maximum knee flexion.

## RESULTS AND DISCUSSION

At no point was the compressive load in the medial or lateral compartment measured to be zero during the trials (Figure 1). The average maximum compressive load seen in the lateral compartment was 0.82 BW and for the medial compartment was 1.8 BW. The majority of the load passes through the medial compartment of the knee.

Calculation of kinetics at each knee flexion angle gave an average external knee flexion moment of 2.9, 5.7, 5.9, and 8.5%BW\*Ht each flexion angle. The maximum flexion moment occurred near the same time as the maximum medial compartment compressive load. The knee had an average external adduction moment of 0.7, 0.6, 0.5 and 0.7%BW\*ht at each flexion angle.

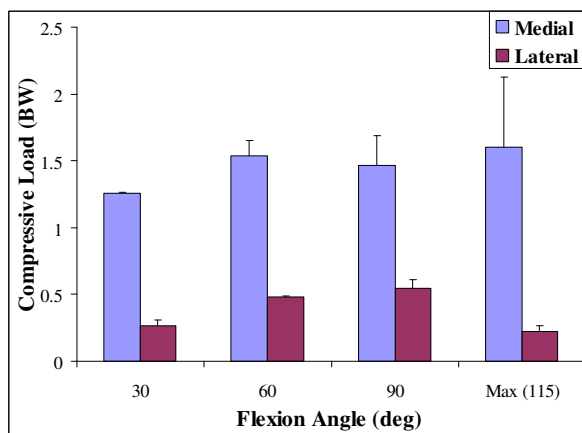


Figure 1: Medial and lateral compartment compressive forces during the squat

## SUMMARY/CONCLUSIONS

The results of this study show that lateral lift off did not occur during the activity studied. Insall et al (2002) had reported variable results for his lift-off study. Their subject's data fluctuated as to which condyle lifted off the tibial plateau when measured at 0°, 30°,

60°, and 90°. Our study show compressive loading during each of the measured flexion angles. The subject studied did not have a 0° knee flexion angle to compare.

A previous study of deep squat stated that a high quadriceps moment, an important determinant in compressive loads at the knee, would produce condition where lift off is not likely to occur (Dyrby and Andriacchi 2000, Nagura 2002). In spite of the maximum adduction moment of 0.7%BW\*Ht, no lateral lift off occurred due to the high external flexion moment.

Wimmer (1998) in a retrieval study of tibial plateaus showed that no plateau had scarring on either the medial or lateral sides, indicative of lift-off. This again shows that lift off is not likely for total knee replacement systems.

## REFERENCES

- Andriacchi TP et al. (2004). In *Basic Orthopaedic Biomechanics, 3rd ed.*, 91.
- Bertin, K.C. (2002) *J. Arthroplasty*, **17(8)**, 1040.
- D'Lima, D.D. et al. (2005). *J Biomechanics* 38, 299.
- Dennis, D.A., et al. (1998). *Clin Orthop* **356**, 47.
- Dyrby and Andriacchi (2000). *Proceeding of ASB 2000*, 7.
- Insall J.N. et al (2002). *Clin Orthop* **403**, 143.
- Nagura et al (2002). *J Orthop Research*, **20(4)**, 881.
- Stiehl, J.B. et al. (1995). *J Bone Joint Surg Br* **77**, 884.
- Wimmer et al. (1998). *J Arthroplasty*, **13(1)**, 8.