The function of the two bundles of the posterior cruciate ligament – an in-vivo study using dynamic stereo X-ray system (DSX)

+1Hensler D;1Musahl V;1Ililngworth KD;1Thorhauer ED;1Tashman S;1
+1Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

INTRODUCTION:
The anterolateral (AL) and posteromedial (PM) bundles of the posterior cruciate ligament (PCL) are described to function reciprocally [3,6]. Double bundle PCL reconstruction is aimed at restoring both functional bundles [2, 7]. Current knowledge is obtained mainly from cadaveric investigations and only few studies investigated the PCL under in-vivo conditions [1, 3, 4, 6]. The purpose of this study was to investigate the biomechanical behavior of both functional bundles of the PCL during in vivo weight bearing knee flexion.

MATERIAL & METHODS:
The contralateral, uninjured knees of 6 subjects previously enrolled in a medial meniscal injury study were scanned with computer tomography (CT). The centers of the tibial and femoral footprints for each PCL bundle were identified on the CT-derived tibial and femoral bone models by two independent observers. Each subject then performed a two-leg squat with the knee positioned within a dynamic stereo x-ray (DSX) system while images were acquired at 100 frames/s. The CT and dynamic x-ray images were combined using a model-based tracking technique [5] to reconstruct 3D knee motion. Two 3D vectors were created connecting the origins and insertions of each PCL bundle. The length and elevation (measured from a transverse plane perpendicular to the long axis of the tibia) of the PCL bundle vectors were measured as a function of flexion (from 0° to 90° of flexion). The results were grouped by a range of 10° of knee flexion. Friedman-test as well as a paired Wilcoxon test for post-hoc testing were used for statistical analysis.

RESULTS:

![Fig. 1: Length of the AL and PM bundle of the PCL. An asterisk denotes statistically significant differences in the length of the bundle between flexion angles](image)

![Fig. 2: Elevation of the AL and PM bundle of the PCL. An asterisk denotes statistically significant differences in the length of the bundle between flexion angles](image)

The length of the AL bundle increased from 0° to 90° whereas the length of the PM bundle decreased significantly within the first 10° of flexion and increased again in flexion angles of more than 30°.

Regarding the elevation, a reciprocal behavior of the two bundles was found. The elevation angle of the AL bundle increased with flexion from 0° to 90° whereas the PM bundle decreased throughout the same range of flexion. The average length of the AL bundle at the range from 0°-90° was 27.4mm (SD 4.5) and reached a maximum of 36.7mm (SD 5.1) at the range from 80°-90° whereas the PM bundle had a minimum of 29.1mm at the range from 20°-29° and had a maximum of 33.4mm (SD 6.0) at the range from 80°-90°.

Inter-observer reliability for the AL bundle and PM bundle was 0.989 [95%CI 0.983-0.992] and 0.886 [95%CI 0.832-0.924] respectively. Intra-observer reliability was 0.980 [95%CI 0.970-0.987] for the AL bundle and for the PM bundle 0.903 [95%CI 0.857-0.935].

DISCUSSION:
The results from this study suggest that the AL- and PM-bundles work reciprocally only in the first 20° of flexion and work synergistically at higher degrees of knee flexion. This is in contrast to results from previous cadaveric and in-vivo studies. The two bundles experienced elongation and change in their orientation. The elongation and elevation patterns observed for the AL and PM bundles are important for the understanding of the biomechanical function of the PCL.

SIGNIFICANCE
These data provide a better understanding of the biomechanical function of the PCL bundles and may help to improve the design of the double bundle reconstruction techniques of the ruptured PCL.

REFERENCES: