In Vivo Patellar Tendon Moment Arm and Tibial-Femoral Helical Axis

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INTRODUCTION

To further improve and validate knee joint models and to develop better surgical and rehabilitative protocols for knee joint injury, a complete understanding of *in vivo* knee joint kinematics and kinetics is critical. Specifically, patellar tendon (PT) moment arm length relative to the tibial-femoral finite helical axis (FHA) plays a crucial role in joint tissue loading and thus, by extension, in the etiology of knee joint pathology. Yet a clear quantitative *in vivo* measurement of this important factor is lacking, due to the fact that the majority of previous studies have been 2D, static and cadaver based. A recent study [1] did investigate 3D PT moment arm, but it was limited to a cadaver model. Thus, the purpose of this study was to experimentally quantify the PT moment arm non-invasively and *in vivo* during a volitional leg extension task in healthy volunteers. A secondary goal was to quantify the tibial-femoral FHA in these subjects in order to determine if the tibia primarily rotates or rotates with translation relative to the femur during extension. The final goal was to determine if the rotation and translation of the FHA was consistent across healthy subjects, thus indicating the applicability of a general model.

METHODS

Twenty knees [9M/11F, age=24.5±6.0years, height=172.8±7.7 cm, mass= 65.6± 12.8kg] from fifteen healthy subjects with no prior history of knee problems or pain participated in this IRB approved study. After obtaining informed consent, subjects were placed supine in a 1.5-T MR imager (LX; GE Medical Systems, Milwaukee, WI, USA).

Subjects cyclically extended and flexed their knee in a supine position at 35 cycles/min, aided by an auditory metronome. Using a sagittal imaging plane, which was perpendicular to the femoral epicondyles and bisected the patella, a full fast-PC data set was collected (anatomic and x, y, and z velocity images, temporal resolution=72 ms, imaging time=2:48). The imaging parameters were consistent with prior studies [2]. If time permitted, both legs were studied. Using rigid body mechanics, the 3D attitude of the patella, femur and tibia were quantified through integration of the 3D velocity data [3]. The insertions of the PT were defined in a single time frame and

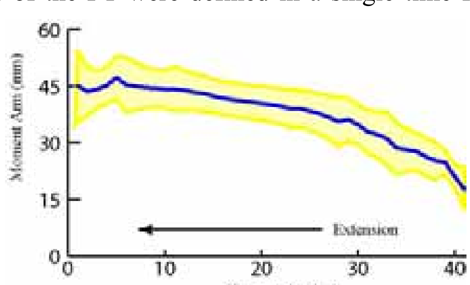

Figure 1: Average Patellar Tendon Moment Arm (blue) ± 1 SD (yellow)

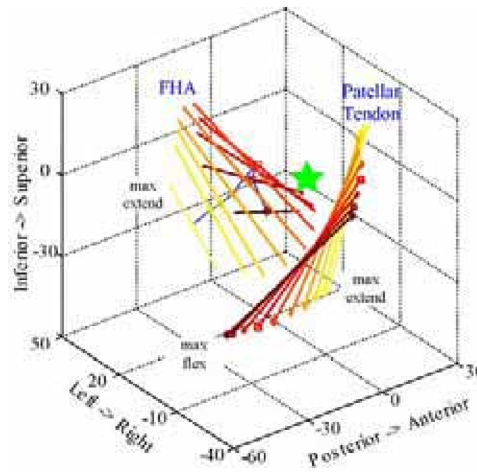

Figure 2: ***FHA and PT Moment arm for Subject 6468R***: The transition from deep red to yellow indicates extension. Deep red line w/ star = full flex ... yellow line w/diamond = full ext. Green star indicates the origin of the femoral coordinate system (0mm,0mm,0mm). The length of the FHA indicates the magnitude of the angular velocity. All axes are in mm.

tracked throughout the cycle based on the 3D patellar and tibial attitude. The FHA was defined by the direction of the angular velocity vector of the tibia relative to femur and the perpendicular vector connecting the tibial origin to the FHA.

RESULTS AND DISCUSSION

All 20 subjects had very similar profiles for the PT moment arm, FHA translation and FHA rotation.. The moment arm increased from max flexion to max extension by 28.4mm (Fig 1). On average, the FHA shifted posteriorly (19.0mm) and superiorly (12.1 mm) and rotated externally (28°) relative to the femoral coordinate system (Fig 2).

This study is the first to measure both the 3D PT moment arm and FHA attitude *in vivo* during a volitional, weighted task using a completely non-invasive measurement system. One interesting point of note is that the moment arm increased as the knee extended, contrary to that which was reported in a recent 3D cadaver study (1). This increase is consistent with the kinematic data collected in that the FHA tended to shift posteriorly while the PT rotated laterally. The discrepancy between these two studies is likely due to the differences in experimental set-up. In addition, the remarkable similarity in kinematic profiles indicates that a general kinematic model may be appropriate for the general population. The next steps in this project will be to determine if these profiles are consistent across an older population and across populations with specific impairments.

REFERENCES

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