EVALUATION OF NATIVE KNEE KINEMATICS AND THE EFFECT OF ARTHROTOMY

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INTRODUCTION

While total knee arthroplasty (TKA) improves postoperative function and pain in the majority of patients with end stage osteoarthritis, the ability of TKA to restore normal knee kinematics is debated. Knee kinematics after TKA can be studied by a variety of methods; however, the most common methods are *in vivo* fluoroscopy [1,2] and cadaveric studies using computer navigation [3,4]. While cadaveric studies using computer navigation are common, most studies do not close the arthrotomy prior to kinematic testing; while accepted in the literature, the impact of arthrotomy on knee kinematics is poorly described. Thus, the purpose of this cadaveric study is to compare the kinematics of the native knee with those from a knee with an opened or closed arthrotomy using a computer navigation system.

MATERIALS AND METHODS

Kinematics of a nonarthritic, fresh-frozen cadaveric knee with an intact PCL were evaluated using a custom software application in an image-free computer assisted orthopaedic surgery (CAOS) system (ExactechGPS, Blue-Ortho, Grenoble, FR). Prior to kinematic testing, four metal hooks were inserted 40 cm away from the joint line, on both the medial and lateral sides of the proximal tibia and the distal femur. A 25N spring gauge was placed on both the medial and lateral side of the knee joint, connecting the tibial and femoral hooks, to simulate natural axial load in the knee joint. Prior to surgical incision for the TKA, one tracker was attached to both the tibia and femur in the diaphysis. Native intact knee kinematics were then assessed by performing passive range of motion three separate times, with the CAOS system measuring and recording anatomical values, including flexion angle, internal/external (IE) rotation of the tibia relatively to the femur, femur tibia anteroposterior (AP) displacement and the Hip-Knee-Ankle (HKA) angle. Next, an anterior incision with a medial parapatellar arthrotomy was performed, and an acquisition of the anatomical landmarks was obtained. The system calculated the previously recorded kinematics within the coordinate system defined by the landmarks [5]. The test was then repeated with closed arthrotomy, and again with opened arthrotomy with patella manually maintained in the trochlea groove. Each recorded anatomical value before and after knee arthrotomy were compared over the range of knee flexion. The deviations in each anatomical value between different knee conditions were compared over the range of knee flexion. Statistical analysis (ANOVA) was performed on the data at ~0° (5°), 30°, 60°, 90° and 120° flexion, with statistical significance defined as $p<0.05$.

RESULTS

The intact knee kinematics were found to be similar to the kinematics with closed and open arthrotomy (Figure 1). Differences between the three situations were found, in average, as less than 0.25° (±0.2) in HKA, 0.7mm (±-0.4) in femorotibial AP displacement and 2.3° (±1.4) in

femorotibial rotation. Although some statistically significant differences were found, especially in the rotation of the tibia for low and high knee flexion angles, the majority is less than 1°/mm, and therefore clinically irrelevant. (Table 1).

DISCUSSION

This study suggests whether the arthrotomy is left open or closed, the knee kinematics compared to a native intact knee are not affected. The small, generally clinically irrelevant differences found at the beginning and end of the test are for the most part within the CAOS system accuracy claim, and the rest are possibly due to human errors during the manual test To the best of the authors' knowledge, this is the first study that show that maintaining the patella in the trochlea groove with an open athrotomy allows accurate assessment of the intact knee kinematics. The level of tibial internal rotation, and its repeatability reported is consistent with previously reported data [6]. Future studies may increase the sample size, and investigate the effect of patella dislocation on the kinematic results. The method presented in this study may also be applied to the investigation of the impact of arthrotomy in OA knees, as OA has been shown to have no impact on the knee kinematics relative to healthy knees [3].

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DISCLOSURES

Yifei Dai, Nicolas Hohl, and Laurent Angibaud are current employees of Exactech Inc.
Fabrice Bertrand and Cyril Hamad are current employees of Blue Ortho SAS.
Jean-Yves Jenny and Michael B Cross are paid surgeon consultants of Exactech Inc.

	flexion (°)	Intact	Closed Arthrotomy	Open Arthrotomy	P Values
Femorotibial AP Displacement (mm)	5	21.75 ± 0.33	20.78 ± 0.63	19.9 ± 0.15	<0.01
	120	-1.75 ± 0.18	-1.59 ± 0.22	-2.56 ± 0.14	<0.01
Femorotibial Rotation (°)	5	2.78 ± 0.39	-0.83 ± 1.31	-0.69 ± 0.67	<0.01
	120	-25.79 ± 0.75	-26.45 ± 0.61	-28.91 ± 0.48	<0.01
HKA Angle (°)	120	178.72 ± 0.12	178.66 ± 0.03	178.99 ± 0.09	<0.01

Indicates clinically irrelevant differences (<1mm/°).

Table 1. Significant differences found between intact knee and knees with open or closed arthrotomy.

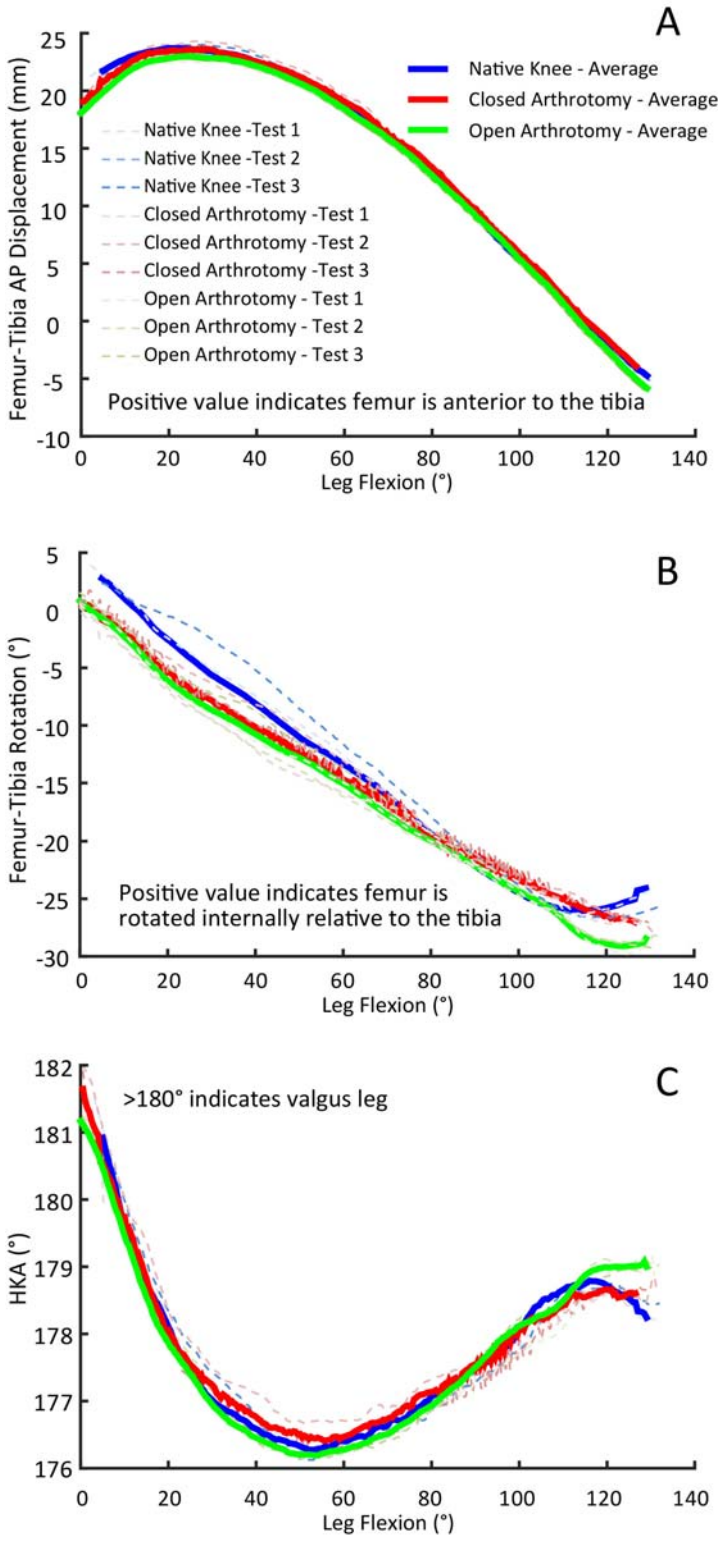

Figure 1. AP position of the femur relative to the tibia (A), IE rotation of the femur relative to the tibia (B), hip-knee-ankle angle (C) as a function of the flexion, compared between the native knee, and the same knee with open and closed arthrotomy.