Tibiofemoral Joint Space Measured During Weight-Bearing Knee Flexion Increases Following TKA

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INTRODUCTION:
Increasing the range of knee flexion following total knee arthroplasty (TKA) remains an important objective for design of new implants and advancement of surgical techniques. With the excellent long term (10-15 year) outcome of TKA, surgeons are more confident about performing the procedure on younger, more active patients demanding increased range of knee flexion [1-3]. Numerous factors have been linked to limited flexion (<120°) following TKA, including patient factors such as preoperative range of motion, intraoperative factors such as component malposition, and implant design [1-3]. Extensor mechanism overstretching due to overstuffing of the knee joint is hypothesized to be a contributing factor limiting knee flexion [1-4]. However, no study to date has investigated the changes in tibiofemoral joint space following TKA. The aim of this study was to examine pre- and post-operative tibiofemoral joint space in a group of TKA patients during weight-bearing knee flexion and to compare it to that in the normal/healthy knee. This could help determine if changes in the proximal-distal distance between the femur and the tibia (tibiofemoral joint space) could lead to extensor mechanism overstretching and consequently limited range of flexion.

METHODS:
Eleven patients with advanced osteoarthritis were recruited preoperatively from the practice of a single surgeon no more than two months prior to their scheduled TKA surgery. Nine patients had predominantly medial compartment osteoarthritis and 2 patients had predominantly lateral compartment osteoarthritis. All patients received cruciate retaining implants (CR Flex, Zimmer Inc., Warsaw, IN). The study was approved by our Institutional Review Board and informed consent was obtained from all study participants. During the preoperative visit, a magnetic resonance (MR) scan of the affected knee was obtained using a 3T scanner. Patients were then asked to perform a static lunge activity from full extension to maximum flexion while images were taken using a dual fluoroscopic imaging system [5]. Six months after surgery, the patients’ knees were re-imaged using the fluoroscopic setup, while performing the same lunge activity from full extension to maximum flexion. MR images were not acquired during the post-operative visit. The pre-operative MR images were used to create patient specific bone models and coordinate systems were established on the tibia and femur based on the bony anatomy [6]. Next, the fluoroscopic images and the bone models were imported into a virtual fluoroscopic setup in solid modeling software, and the bone models were matched to the fluoroscopic images to reproduce the knee flexion path pre- and post-TKA surgery [5, 6]. For the post-operative images, 3D models of the TKA were also matched to the corresponding fluoroscopic images. From the matched knee positions, the proximal-distal distance between the femur and tibia was determined pre- and post-TKA (Fig. 1), from 0° to 105° flexion at 15° intervals. The proximal-distal distance between femur and tibia for 20 healthy subjects (12 male, 10 female, avg. age 31 ± 9 yrs) were used as a normal control. This data were obtained from previous studies using identical protocol and coordinate system definition [6].

RESULTS:
Overall the (average) distance between the femur and tibia was greater post-operatively compared to both pre-operative values and values for the normal control group (Fig. 2). The average increase in the tibiofemoral joint space following TKA (post-op – pre-op), ranged from 1.5 ± 2.7 mm at full extension (0° flexion) to 3.1 ± 2.3 mm at 105° flexion (Fig. 2). The normal control and post-operative values were similar in magnitude from 0° to 60° flexion (difference <0.5mm). However, between 75° and 105° flexion the tibiofemoral joint space was greater for post-operative knees compared to normal knees.

DISCUSSION:
In this study we investigated the distance of the femur relative to the tibia (tibiofemoral joint space) during weight bearing flexion in a group of 11 TKA patients both pre- and post-operatively. To the best of our knowledge this is the first study reporting a direct comparison of tibiofemoral joint space pre- and post-TKA during weight-bearing knee motion. The results showed that the post-operative joint space was larger than pre-operative values at all measured flexion angles, and post-operative joint space was larger than normal values at flexion angles > 75°. This increase may indicate that the knee is overstuffed after total knee replacement. In literature, overstuffing of the knee joint has been recognized as an important factor that contributes to limited knee flexion [1-4]. The tightness felt by the patients post-operatively at maximum flexion in our study, suggests that overstuffing the knee after TKA might cause overstretching of the extensor mechanism and other soft tissues around the knee joint such as the collateral ligaments and the joint capsule, thus limiting further knee flexion. Continuing work includes recruitment of larger patient cohort and evaluation of quantitative correlation between maximum knee flexion and increase in tibiofemoral joint space after TKA. The surgical and implant design factors underlying possible increases in tibiofemoral gap will also be investigated.