INTRODUCTION

Routinely in total knee arthroplasty (TKA), at least one of the cruciate ligaments are sacrificed. The cruciate ligaments excision may have an impact in the stability of the reconstructed knee by virtue of the impact on the gap kinematics. These gap kinematics are present throughout the entire range of motion but are only typically addressed in full extension and at 90° flexion during TKA. In this study, a selective cutting protocol was designed to quantify the individual contribution of key ligaments and capsular elements about the knee by means of a loaded cadaveric model.

METHODS

Five fresh frozen normal cadaver specimens were used. Computer tomography scans were performed in order to obtain detailed three dimensional configurations of the femur and the tibia. Skin and subcutaneous tissue were removed. Insertion of all tendons and ligaments around knee joint were left intact. The femur was fixed to a specially designed machine so that the central axis of the tibial shaft was perpendicular to the ground. Ten pounds were applied at the ankle to distract the knee joint. The knee flexion was created by elevating the femur. Three dimensional tibial movements relative to the femur (medial/lateral, anterior/posterior, inferior/superior, varus/valgus, external/internal rotation) and medial and lateral joint gap distances were measured by means of a navigation system (Stryker® Orthopaedics, Mahwah, NJ, USA) from full extension to 140° flexion. The data was transferred to the personal computer, and the analysis was performed based on the computer tomography data. The joint gap distance was defined as the narrowest distance between the femoral and the tibial articular surfaces at each flexion angle. The ligaments were excised step by step. The order of the excision was ACL, PCL and deep layer of MCL. After each excision, the capsule was sutured firmly. The measurement was performed before and after each step.

RESULTS

Results of medial gap distances from full extension to 130° flexion are shown in Fig. 1. Medial gap distance at 90° knee flexion before and after both cruciate ligaments excision was 4.3 ± 2.7 mm (mean ± SD) and 5.1 ± 2.8 mm (p<0.05) respectively. Cruciate ligaments excision significantly widened the medial gap at many flexion angles. After cruciate ligaments excision, the release of the MCL deep layer did not have a significant effect on the medial joint gap. Cruciate ligaments excision also significantly influenced the lateral gap distance. The effect of cruciate ligaments excision on the gap distance was different between medial and lateral sides especially at 90° knee flexion (Fig. 2). The result of the effect of cruciate ligaments excision on varus/valgus angles of the tibia relative to the femur is shown in Fig. 3. The tibia tilted significantly in varus position after cruciate ligaments excision in the early flexion. Cruciate ligaments excision also significantly influenced lateral/medial, inferior/superior anterior/posterior movements of the tibia relative to the femur especially in the early flexion.

DISCUSSION

Cruciate ligaments excision had a demonstrable impact on the gap present during a simulated range of motion performed under tibial tension. The effect of ACL excision was larger than that of PCL excision especially in early flexion. If this varying gap is not accounted for either through implant shape and orientation or through soft tissue adjustments, instability could be the result. The dynamic gap analysis showed important differences in the impact of the cruciate ligaments excision. In the measured bone resection technique, the size of the femoral component is decided based on the size of the distal femur, and distal femoral and anterior/posterior bone cuts are made based on the bony landmarks without taking the impact of the cruciate ligaments excision and MCL releases into account. Therefore, the knees with anatomical sized femoral component may have instability throughout the range of motion. The external rotation angle of the femoral component that is decided based on the anatomical bony landmarks may also induce varus/valgus instability. Surgeons should be made aware of the influence of cruciate excision on varus/valgus laxity throughout the range of motion. The gap control technique may be more reliable because equal rectangular joint gap is made between in full extension and at 90° knee flexion. Even in the gap control technique, stability/flexibility in the deep flexion should be taken into account. Fig. 2 demonstrates that the joint gap distance was different between 90° and 120° flexion. In the current operative technique, the joint gap is not assessed at 120° flexion. In order to obtain the optimal stability/flexibility both at 90° flexion and in the deep flexion, modification of the operative technique, such as excessive external rotation of the femoral component, may be necessary because the lateral joint gap is wider.1 Design modification of the femoral component may also be necessary in order to obtain optimal stability in deep flexion.