INTRODUCTION

Accurate knowledge of 3D tibiofemoral articular contact locations of the knee after TKA is crucial for enhancing patient function and preventing component wear and failure. Recently, fluoroscopic imaging techniques have been used to measure knee kinematics after TKA [1, 2]. These studies determined the knee kinematics utilizing a single sagittal plane image of the knee at each target flexion angle, and this method has been limited in its ability to measure 6DOF knee kinematics [3]. In fact, these studies only reported the movement of tibiofemoral contact point in the anterior-posterior direction. In order to accurately determine the actual contact points on the tibial plateau, this study utilized a recently developed dual-orthogonal fluoroscopic imaging technique [3] to quantify the 6DOF knee kinematics and determine the tibiofemoral contact points on the tibial plateau surface using a group of patients after cruciate retaining TKA.

MATERIALS and METHODS

Four TKA patients with CR components (NexGen CR, Zimmer, Warsaw, IN) (age 45-65, male) were scanned while performing a single leg lunge using two fluoroscopes (GE 9800, GE Medical, Salt Lake City, UT) positioned in an orthogonal manner. The knee was scanned at approximately every 10° from full extension up to maximal flexion. The orthogonal images and a 3D CAD model of the corresponding TKA were used to create a virtual dual-orthogonal fluoroscopic imaging system (Fig. 1). The TKA component position was adjusted in all 6DOF within the virtual system until the projections of the tibia and femoral components matched the patient’s TKA images captured during the actual weightbearing flexion. The in-vivo TKA position at each flexion angle was therefore reproduced using the TKA models. From these TKA models, the tibiofemoral articular contact was determined by the overlapping of the tibiofemoral articular surfaces. The contact point was defined as the centroid of the contact area. In this study, contact points were determined on both medial and lateral tibial component surfaces. Each patient was individually investigated, and the motion ranges in anterior-posterior (AP) and medial-lateral (ML) directions were reported.

RESULTS

Patient 1 (Fig. 2A): On the medial side, the contact point was initially behind the central line. It moved anterior to the central line and slightly medially and then remained in the same location with further knee flexion. It moved posterior again at high flexion angles. The motion range was 7 mm in AP direction and 4 mm ML direction. On the lateral side, the contact point was on the anterior portion at full extension. It moved posteriorly with flexion with a motion range of 20 mm in AP and 9 mm in ML directions.

Patient 2 (Fig. 2B): On the medial side, the contact points were located at the central portion. It moved anteriorly then posteriorly with an AP motion range of 8 mm and a ML motion range of 8 mm. On the lateral tibial plateau, the contact points were all located at the posterior portion with an AP motion range of 3 mm and ML range of 4 mm.

Patient 3 (Fig. 2C): On the medial side, the contact points moved posteriorly and then anteriorly with an 9 mm AP range of motion and 4 mm ML range of motion. On the lateral side, the contact points were all at the center portion of the tibial platea. The overall motion range was 8 mm in AP and 3 mm ML directions.

Patient 4 (Fig. 2D): On the medial side, the contact points were all on the posterior half of the tibial component. The AP range of motion was 6 mm while the ML motion range was 11 mm. On the lateral side, the contact point initially moved posteriorly and then anteriorly. The overall AP motion range was 9 mm and ML motion range was 3 mm.

DISCUSSION

This paper presented a patient-specific investigation of tibiofemoral contact kinematics during a weightbearing flexion of the knee after a CR TKA using a non-invasive imaging technique. The data included not only the contact point motion range in both AP and ML directions, but also the actual locations of the contact points on the tibial component surfaces. Even though the motion ranges in both AP and ML directions are similar among the patients, their locations on the tibial plateau surfaces varied.

These data provided in-vivo initial boundary conditions for advanced finite element analysis of in-vivo stress-strain distribution in daily activities of the patients. Therefore, it is possible to perform custom-analysis of the polyethylene wear pattern and failure mechanism for individual patients.