IN VIVO KINEMATICS OF UNIMPLANTED KNEE USING FLUOROSCOPY/3D-CT REGISTRATION

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INTRODUCTION

We had reported the in vivo kinematics of the metallic knee prosthesis [1] using feature-based 2D (fluoroscopy) to 3D (CAD: computer assisted design model) registration technique [2,3]. The aim of the current study was to build an analyzing system of unimplanted normal knee kinematics utilizing this feature-based 2D/3D registration technique, and to evaluate the accuracy of pose estimation for each unimplanted knee bone using computer simulation test.

METHODS

Multidetector Computed Tomography (MDCT) data, the 1-3mm axial slice with 512 x 512 image matrix, from healthy volunteer was used to create 3D bone surface models of femur, tibia/fibula and patella. Segmentation of the bone was performed by applying a thresholding filter.

Under fluoroscopic surveillance in the sagittal plane, dynamic knee motion was recorded as serial digital x-ray images (1024 x 1024 x 12 bits/pixels, 7.5Hz serial spot images as a DICOM file) using a 12" digital image intensifier system (C-vision PRO-T, Shimadzu, Japan) and a 1.2-2.0 msec pulsed x-ray beam.

In vivo spatial posture of the unimplanted normal knee was estimated using 2D/3D registration technique [2,3] (Figure. 1). As for the contour detection a closed contour of the bone was not required. For the pose estimation, the bone model surface must be tangent to the projection lines coming from certain contour points. 3D bone models after computation reproduce 6 degrees of freedom (DOF) of each bone from calibrated (including distortion correction) single-view fluoroscopic images.

RESULTS

Chair rise : During chair rise activity, from 103.3 degree of flexion to 2.3 degree of hyper-extension, femur exhibited 20.8 degree of internal rotation relative to tibia (Figure. 2). Femorotibial contact position of both condyles shifted anteriorly 9.2mm medially and 34.7mm laterally, respectively (Figure. 3). During arising from a chair, medial pivoted screw home movement was observed (Figure. 4).

DISCUSSION

Feature-based 2D/3D registration for the kinematic analysis of unimplanted knee using single-plane fluoroscopy and 3D-CT was performed successfully. Relatively large rotation error of patella can be explained by poor geometrical feature of patella. The algorithm of current study was suit for pose estimation of unimplanted bones because complete contour detection for fluoroscopic image was no needed, although the contours of fluoroscopic bone images are not sharp like with a metallic prosthesis.

REFERENCES