A FLUOROSCOPIC ANALYSIS OF A MOBILE BEARING DESIGN

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Introduction

Recent studies (Banks et al., 1997; Sthiel et al., 1997) have pointed out that total knee replacement (TKR) kinematics can be different from the intact knee and even from prosthesis design expectations. Tools for the accurate measurement of in-vivo kinematics of prosthesis components are fundamental to compare the kinematic patterns associated to different designs, to test new designs and to collect valuable information for devising new types of implant which could better replicate normal knee functions. The purpose of this study was to analyse the kinematics of a mobile bearing TKR (InteraxISA, Stryker/Howmedica/Ostetronics) during daily living activities.

Methods

Nine TKR patients with excellent clinical outcome were studied during stair climbing, sit-to-stand/stand-to-sit and step up/down activities by means of fluoroscopic analysis. This study implemented a technique for 3D kinematic analysis of a known object from a single view. The technique was applied to a sequence of images acquired at 4 frame per second from a standard fluoroscope with 32-cm field of view. A typical example is given in Figure 1. The position of the camera focus with respect to the image plane is fixed and calibrated at the beginning of each experimental session. For image distortion correction a spatial warping technique is applied. Prosthesis component positions were obtained from each fluoroscopic image by an iterative procedure using a CAD-model-based shape matching techniques. In Figure 2 a result of the procedure applied on a fluoroscopic image of a patient during sit-to-stand activity is shown. Previous (Banks et al., 1996) validation work has shown that orientation and translations in the sagittal plane of the prosthesis components can be estimated with an accuracy better than 1 degree and 0.5 mm, respectively. Knee rotations were computed using the Grood and Suntay (1983) convention.

Figure 1 Fluoroscopic image of a patient during sit-to-stand/stand-to-sit activity. Tantalum markers inserted in the mobile bearing are evidenced with red circles.

The location of the two femoral contacts on the tibial insert were computed as the points on the condyles closest to the plane of the tibial plateau. Tantalum markers inserted in the mobile bearing also allowed the movement of the insert to be tracked with respect to the tibial plateau in the sit-to-stand/stand-to-sit and step up/down activities. Tantalum markers are detectable in Figure 1 between the two metal prosthesis components.
Results & Discussion

During stair ascending, sit-to-stand/stand-to-sit and step up/down activities the range of tibial/femoral flexion/extension was 39-86°, 70-93° and 44-92°, respectively. The range of in/external rotation was 1-19°, 3-11° and 5-15°, respectively. Physiological and non physiological screw-home mechanism was observed in the patients analysed. In all motor tasks the range of ab/adduction was less than 4°. In these three motor tasks the medial condyle contact point (CCP) moved 3-15 mm, 3-17 mm, 7-15 mm peak to peak and the lateral CCP moved 3-20 mm, 4-12 mm, 4-12 mm peak to peak. Femoral roll-back was rarely observed. In figure 3 the mean values over the 9 patients of flexion/extension, ab/adduction, in/external rotation (on the left), medial CCP, lateral CCP and mid point between lateral and medial CCP (on the right) during stair ascending are reported.
The anterior/posterior displacement of the insert with respect to the tibial component was 1-6 mm and 3-6 mm, respectively, and the in/external rotation was 2-9° and 5-12°, respectively.

Some motion, however small, of the insert was observed and interpreted as adjustment/adaptation of the three part prosthesis. The kinematics behavior of the mobile insert was different from patient to patient.

References

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