Title: The innovation of orthopedic surgery ---- by the development of in vivo 3D kinematic analysis system -----

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One of the purposes of orthopedic surgeons is a joint recovery of the patients which consists of a pain relief and a normal function. The functional evaluation is essential to estimate the clinical results, and it is enabled by the analysis of the joint kinematics. Thousands of cadaveric studies were already reported but those may differ from the in vivo condition for lack of ligamentous or muscular effects. In the analysis system, plain X-ray only gives us two dimensional information and it is not sufficient for the 3D analysis. 3D CT or MRI are only the device to visualize the structure under the static conditions. Development of in vivo 3D kinematic analysis system are really needed for the diagnosis of pathological movement or the evaluation of postoperative function. Two systems were developed in our institute. One is a system using 3D CT or MRI and it is very available for the analysis of the joint movement. The targeted joint is placed in serial positions of the motion plane to evaluate 3D kinematics of the motion, and the images are obtained in each position. The data are saved and transmitted to a computer workstation, where image processing such as segmentation and volume registration are performed using a software program developed in our laboratory. Segmentation is defined as extracting the contour of the bone required for processing, which is semi-automatically segmented by intensity thresholding techniques. Voxel based registration is an image processing method for matching volume images based on voxel values. Kinematic variables are measured by automatically superimposing segmented 3D MRI or CT of the bones in the neutral position over images for each position using this method of registration. The correlation coefficient is used as a method of measuring similarity of voxel values for registration. With this method of measuring, a matrix that allowed for the maximal correlation of the two images is calculated. Animations of the joint movement are created from the calculated motions and surface bone models that were reconstructed from 3D-MRI data using the marching cubes algorithm in the Visualization Toolkit (VTK). This method is available for the in vivo 3D kinematic analysis of any joint. The scapulo-thoracic, gleno-humeral or aclomio-clavicular motions were already studied in the shoulder joint, while the tibio-femoral of patello-femoral motions

were also studied in the knee joint. The other is a system using a radiographic image intensifier. It can evaluate real-time 3D dynamic motion of the metal implant and it is very available to evaluate the kinematics after the arthroplasty. The 3D pose-estimation technique is built on a 2D/3D registration algorithm, which determines the spatial pose for each component from the implant contours and computer-assisted design (CAD) models of the implant. The way of kinematic analysis after TKA is explained by way of example. Sequential fluoroscopic images are taken in the sagittal plane during loaded knee bending motion, walking or stairing. The difference of kinematics in various types of implants were clarified.

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