Utilisation de capteurs cinématiques en trois dimensions pour choisir entre prothèse totale de genou à plateau fixe et à plateau mobile

Responsable
Jolles Brigitte (hôpital orthopédique)

En partenariat avec
Pichonnaz Claude (HESAV), Aminian K.; Dejnabadi H., EPFL, M. Voracek K. Leyvraz, P. F., Hôpital Orthopédique

Mots-clé
Prothèse total de genou, outcome, cinématique

Durée
2003-2007

Résumé

The importance of evaluation of an orthopedic operation such as hip or knee arthroplasty has long been recognized. Many definitions of outcome and scoring questionnaires have been used in the past to assess the outcome of joint replacement. However, these assessments are subjective and not accurate enough. In addition, orthopedic surgeons require now more subtle comparisons between potentially efficacious treatments (e.g. two types of prostheses). Therefore, the use of objective instruments that have a better sensitivity and specificity than traditional scoring systems is needed. Gait analysis is one of the most currently used instrumented techniques in this respect. However, a gait analysis system is accessible only in a few specialized laboratories, as it is complex, expensive, need a lot of room space and fixed devices, and not convenient for the patient.
In this thesis, we proposed an ambulatory system based on kinematic sensors attached on the lower limbs to overcome the limitations of the previously mentioned techniques. Technically the device is portable, easily mountable, non-invasive, and capable of continuously recording data in long term without hindrance to natural gait. The goal was to provide gait parameters as a new objective method to assess Total Knee Replacement (TKR). New solutions to fusing the data of accelerometers and gyroscopes were proposed to accurately measure lower limbs orientations and joint angles. The methods propose a minimal sensor configuration with one sensor module mounted on each segment. The models consider anatomical aspects and biomechanical constraints. In the proposed techniques, the angles are found without the need for integration, so absolute angles can be obtained which are free from any source of drift. These data were then used to develop a gait analysis system providing spatio-temporal parameters, kinematic curves, and a visualization tool to animate the motion data as synthetic skeletons performing the same actions as the subjects. Moreover, a new algorithm was proposed for assessing and quantification of inter-joint coordination during gait. The coordination model captures the whole dynamics of the lower limbs movements and shows the kinematic synergies at various walking speeds. The model imposes a relationship among lower limb joint angles (hips and knees) to parameterize the dynamics of locomotion for each individual. It provides a coordination score at various walking speeds which is ranged between 0 and 10. An integration of different analysis tools such as Harmonic Analysis, Principal Component Analysis, and Artificial Neural Network helped overcome high-dimensionality, temporal dependence, and non-linear relationships of the gait patterns.
In order to show the effectiveness of the proposed methods in outcome evaluation, we have considered a clinical study where the outcomes of two types of knee prostheses were compared.

We conducted a randomized controlled study, including 54 patients, to assess TKR outcome between patients with fixed bearing and mobile bearing tibial plates of implants. The patients were tested preoperatively and postoperatively at 6 weeks, 3 months, 6 months, and 1 year. Various statistical analyses were done to compare the outcomes of the two groups. Finally, we provided objective criteria, using ambulatory gait analysis, for assessing functional recovery following TKR procedure. We showed significant difference between the two groups where the standard clinical evaluation was unable to detect such a difference.

Publications

Pichonnaz, C ; Voracek, C.; Jollès, B. M.; Dejnabadi, H.;Aminian K. L'intérêt d'un dispositif portable d'analyse du mouvement : illustration à partir d'une étude comparant les prothèses de genou à plateau fixe et à plateau mobile Congrès de la revue romande de physiothérapie Mains Libres, Lausanne, novembre 2005,

Objective analysis of gait coordination for total knee arthroplasty outcome, Jollès, B. M.; Dejnabadi, H.; Martin, E.; Voracek, C.; Pichonnaz, C.; Leyvraz, P. F.; Aminian, K. EFFORT Florence Italie 11 - 15 mai 2007.