3D KINEMATICS OF A TOTAL KNEE ARTHROPLASTY DURING STAIR DESCENT: VIDEO-PHOTOGRAMMETRY VS VIDEO-FLUOROSCOPY

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INTRODUCTION

Stair descent is known to provide discomforts to subjects who exhibit muscle weakness and disorders at the knee joint. Therefore, it is described as a difficult, risky and painful task [1]. Moreover, several studies reported the highest loads at the knee for stair descent apart from jogging [2]. Stacoff et al. (2005) showed that more demanding activities such as stair descent need to be analyzed in order to understand a pathological or prosthetic knee motion pattern [3].
Although video-photogrammetry in combination with external skin mounted markers is regarded as the most common tool employed in gait analysis, biomechanical laboratories are making more and more use of techniques with greater accuracy such as video-fluoroscopy [4].
Our goal was to assess the three dimensional kinematics of a total knee prosthesis during unconstrained stair descent by means of video-photogrammetry and video-fluoroscopy.

METHODS

A 5-years postoperative subject was recruited for the study. The implanted prosthesis was a posterior cruciate retaining design with a congruent fixed bearing (BalanSys, Mathys Orthopeadics, Switzerland).
The measuring equipment consisted of a twelve camera video-photogrammetry system (Vicon, Oxford, UK), a three step instrumented stair (Kistler, Switzerland) and a two degrees of freedom automated moving fluoroscope (BV Pulsera, Philips Medical Systems, Switzerland) [5].
The rotations assessed by means of video-photogrammetry were described by the motion of the thigh with respect to the shank. A marker clustering method was adopted to identify the segments. The flexion axis was delineated as the optimal axis during fifteen weight bearing isolated knee flexions.
The rotations of the femoral implant component were described with respect to the tibial tray. The flexion axis was defined as the axis passing through the centers of curvature of the two femoral condyles. The internal-external rotation was identified as the displacement about the vertical axis of the tibia and the varus-valgus rotation the movement about the anterior-posterior axis of the implant.

RESULTS AND DISCUSSION

The range of motion (ROM) of the knee joint rotations that was determined by means of video-photogrammetry data resulted to be 77.1°±1.3 for flexion, 4.3°±0.7 for varus and 7.4°±1.5 for internal rotation, while video-fluoroscopy data returned values of 84.6°±1.9, 3.1°±0.7 and 6.8°±0.8 respectively. Although the flexion trajectories showed a similar path, video-photogrammetry data underestimated the actual motion of the implant (Figure 1). With respect to varus-valgus rotation, photogrammetry data overestimated the movement of the knee during the second half of the stair cycle. Furthermore, the trajectory exhibited a different path after toe off. Although ROMs in internal-external rotation were similar, the femur showed an erroneous motion pattern when it was described by means of photogrammetry data.

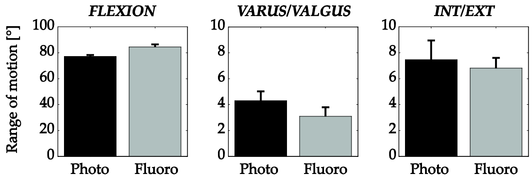

Figure 1: Range of motion (mean and standard deviation) of flexion, varus-valgus and internal-external rotation over five trials calculated by means of video-photogrammetry (Photo) and video-fluoroscopy (Fluoro).

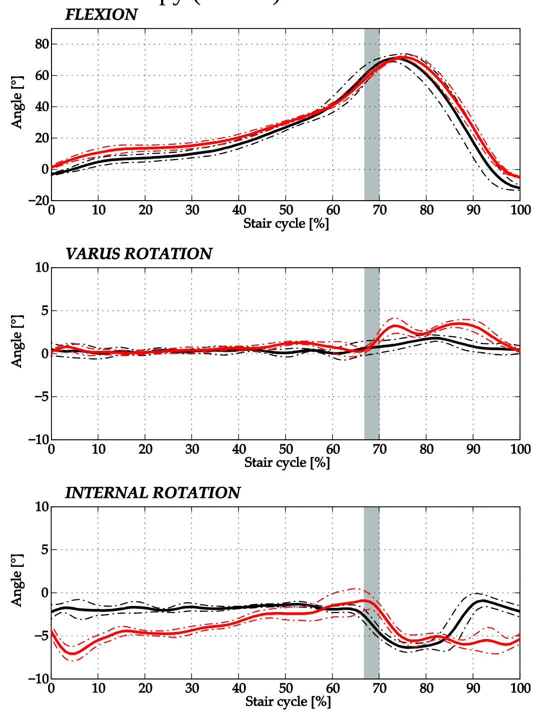

Figure 2: Rotations at the knee joint determined by means of photogrammetry (red) and fluoroscopy (black). The solid and the dotted line represent the mean average and the corresponding standard deviation over five trials. The vertical grey bar indicates the variation of the toe off event.

CONCLUSIONS

In our study, we found that knee joint movements during stair descent can be substantially misinterpreted when using video-photogrammetry data. Therefore, it is essential that more accurate measurement setups are used to evaluate problematic human motion patterns such as stair descent.

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