

Do Spinopelvic Characteristics Exhibited During Gait Normalize Post-THA? – A Prospective, Case-Control, Comparative Study Using 3D Motion Capture Analysis

Nicholas Ryan¹, Erik Kowalski¹, Danilo Catelli¹, Mario Lamontagne¹, George Grammatopoulos²

¹ Human Movement Biomechanics Laboratory, University of Ottawa, Ottawa, Canada, ²Division of Orthopedic Surgery, The Ottawa Hospital, Ottawa, Canada

nryan@uottawa.ca

INTRODUCTION: Pre-operative spinopelvic characteristics have been proposed as a factor that may influence surgical outcomes (eg. dislocation risk) following total hip arthroplasty (THA), due to compensatory movement patterns in the hip joint and/or intervertebral joints. Surgeons are therefore encouraged to consider a patient's spinopelvic characteristics during pre-surgical planning. However, radiographic assessment has indicated that compensatory movement patterns during static postures resolve post-THA. These findings have been replicated in dynamic seated tasks, but have not yet been extended to gait. The purpose of this study was to examine whether and to what extent adverse spinopelvic characteristics normalize during gait following THA surgery.

METHODS: Fifteen patients (65.7±6.8yrs, M=7, F=8) who received THA for the treatment hip osteoarthritis, underwent 3D motion-capture analysis of their gait kinematics within one month prior to (PRE group) and 12 months after surgery (POST group). A healthy control group of nine participants (47.5±16.5yrs, M=4, F=5) was also assessed (CTRL group). Subjects performed a gait task over a distance of 8m on a level surface at their own self-selected speed. Spinal range of motion was assessed in the sagittal, frontal and transverse planes, while statistical parametric mapping (SPM) was used to detect the presence and timing of significant differences in spinal kinematics during the gait cycle (foot strike to ipsilateral foot strike). Spatio-temporal gait parameters (walking speed and stride length) were also measured using the motion capture heel markers, and normalized to leg length.

RESULTS: The PRE group walked significantly slower than the CTRL group, and with a shorter stride length. Following surgery, significant improvements were observed in the POST group but both variables remained significantly different to the CTRL group. For spinal range of motion during a gait cycle on the affected side, the PRE group demonstrated significantly less frontal plane motion, compared to the CTRL group (6.2° vs 13.6°; $p = 0.001$). No significant differences in sagittal or transverse ranges of motion were detected. Following surgery, significant increases were observed in frontal (6.2° vs 8.6°; $p = 0.011$) and transverse (10.4° vs 15.5°; $p = 0.003$) plane ranges of motion, but not in sagittal plane motion. Compared to the CTRL group, the POST group no longer differed in transverse plane motion (15.5° vs 13.3°, $p = 0.474$), but retained significantly less frontal plane motion (8.6° vs 13.6°; $p = 0.030$) and now exhibited significantly more sagittal plane motion (5.6° vs 3.7°; $p = 0.04$). The SPM analysis identified significant transverse plane differences between the PRE and POST groups from 0% to 32% and 88% to 100% of the gait cycle. During these periods, the POST group displayed a higher degree of rotation (pelvis rotating anteriorly on the side of the leading limb). The POST group also displayed significantly more transverse motion than the control group from 14% to 31% of the gait cycle. No differences were detected between the PRE group and the CTRL group. In the frontal plane, no significant differences were detected between any of the three groups throughout the gait cycle.

DISCUSSION: In the transverse plane, both the ROM and the SPM analyses showed evidence that spinal motion during gait improved following THA, but was not necessarily abnormal before surgery. Differences were most evident when the affected limb was in a position of flexion and the pelvis was rotated anteriorly on that side. In the frontal plane, the ROM analysis indicated improvement but not to the point of normalization, while the SPM analysis demonstrated relatively normal movement patterns before and after surgery. Spinopelvic characteristics during gait are not universally abnormal prior to THA, but show improvement when they are. Normalization appears to be more evident in tasks that require greater spinopelvic motion than is exhibited during gait.

SIGNIFICANCE/CLINICAL RELEVANCE: The importance of a patient's spinopelvic characteristics in pre-surgical planning for THA is not clear. Pre- and post-operative assessment of how they change may better inform this important factor in surgical outcomes.

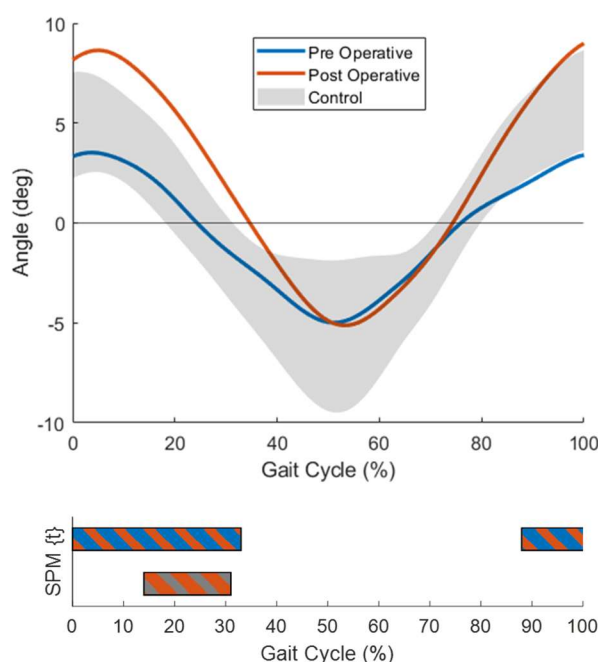


Figure 1. SPM analysis of transverse plane motion in PRE, POST and CTRL groups during gait.

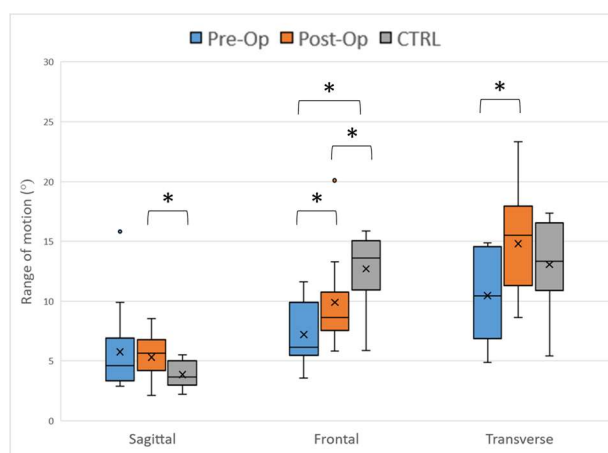


Figure 2. ROM analysis of 3D spinal motion in PRE, POST and CTRL groups during gait. * = significant differences at $p < 0.05$