Sagittal Plane Kinematics Following Total Hip Arthroplasty Using Direct Anterior Approach

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INTRODUCTION: Osteoarthritis (OA), a joint disease characterized by the degeneration of articular cartilage, bone remodeling and loss of proper joint function, is estimated to affect nearly 240 million people worldwide.[1] For the treatment of advanced OA of the hip, total hip arthroplasty (THA) is an effective and relatively safe procedure, with nearly 90% of patients reporting a significant reduction in pain and improved quality of life.[1,2] While the posterior approach (PA) is most commonly used for THA, the direct anterior approach (DAA) is gaining popularity within the orthopedic community.[3] As this approach does not rely on the detachment of muscle from the pelvis or femur, recent studies have suggested that the DAA could result in improved post-operative outcomes and faster recovery of normal gait kinematics.[3,4] However, there are a limited number of studies investigating long-term muscle activation and symmetry in the sagittal plane following the DAA.[5] This study aims to use motion analysis to compare sagittal hip plane kinematics in subjects at least 1 year after unilateral DAA for THA, particularly at normal and increased walking speeds over level ground to induce greater hip extensor activation. We hypothesize that sagittal plane hip motion will remain symmetrical but display increased range bilaterally at walking speeds 10% greater than each person's self-selected walking speed.

METHODS: Subjects who underwent a unilateral THA for hip OA at our institution were recruited for this IRB-approved study. Eleven participants who underwent DAA for THA provided written informed consent and completed this study. After providing consent, subjects were prepared for motion and strength analysis at the Center for Motion Analysis (CMA). Hip strength was tested by the same trained assessor for each participant in all three planes via a Micro-Fet handheld dynamometer. Various anatomical measurements were performed for each subject, including height, weight, leg lengths, ankle and knee widths, and inter- anterior superior iliac spine (ASIS) distance. Reflective markers were then adhered to subjects' skin at anatomical landmarks on the sacrum and bilateral ASIS, patella, lateral femoral epicondyle, lateral and medial malleolus, calcaneus, and second metatarsal. Participants completed 10 successful dynamic trials of level, over-ground walking at their self-selected speed along the 30-foot long CMA walkway. Participants then completed 10 dynamic trials at a walking speed 10% higher than their self-selected speed. A metronome was used for all trials to ensure cadence consistency. Vicon's Plug-in Gait (PiG) model was used to generate kinetic and kinematic data for self-selected and 10% faster walking speeds. Sagittal plane kinematics were compared across the gait cycle using Welch's t test with significance set to $p \leq 0.05$.

RESULTS: Sagittal plane hip kinematics for a total of 11 subjects who underwent DAA were included in this study. There were no significant differences between the unaffected and affected sides throughout the gait cycle. Sagittal plane ankle dorsiflexion was significantly decreased ($p < 0.05$) during early load response of gait on the affected side compared to the unaffected side at both self-selected and 10% faster walking speeds (Figure 1A, Figure 1B). At increased walking speeds, there was significantly greater ($p < 0.05$) hip flexion during the load response, midswing and terminal swing of the gait cycle and greater hip extension during the midstance when compared to self-selected walking speeds (Figure 1C). There were also significant differences ($p < 0.05$) in ankle angles during the midstance and preswing phases of gait, foot progress angles during the preswing, knee angles during the load response, midstance, terminal stance and preswing, and pelvic angles during the terminal stance.

DISCUSSION: These results suggest that hip kinematics in the sagittal plane maintain symmetry at both normal and increased walking speeds following DAA and display increased hip range of motion at increased walking speeds. The restoration of natural gait kinematics is vital to successful recovery following THA, with sagittal plane hip symmetry supporting the return of normal hip motion. However, post-operative changes in lower extremity joint motion may point to continued compensation for hip musculature deficits. Future studies should compare kinematics in the coronal and frontal planes, muscle activation using EMG data, and post-operative kinematics following the DAA and PA in order to validate the impact of THA approach on long-term clinical outcomes.

SIGNIFICANCE/CLINICAL RELEVANCE: This study provides evidence that natural hip kinematics in the sagittal plane are restored following DAA. Analysis of kinematic differences between unaffected and affected sides and at different walking speeds may illustrate how THA approach affects post-operative recovery.

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A. **B.** **C.**

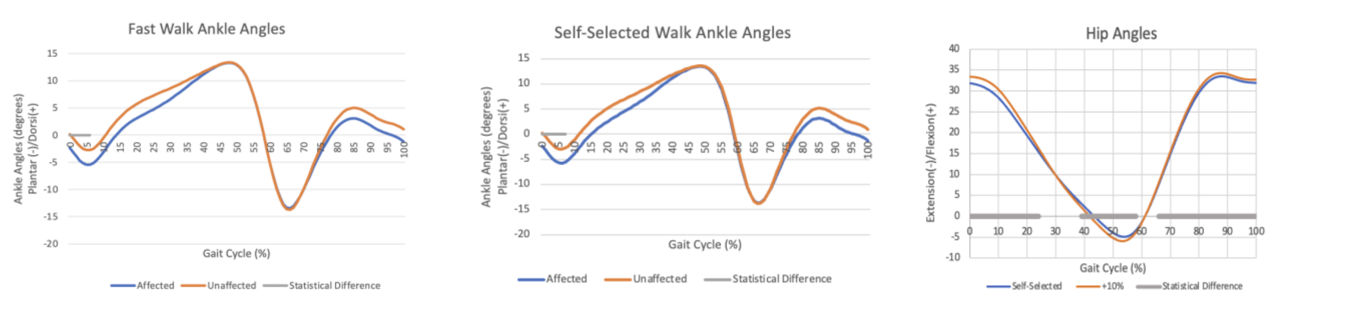

Figure 1: Sagittal plane kinematics following DAA for THA. **A.** Ankle kinematics in affected and unaffected sides at 10% increased walking speeds. **B.** Ankle kinematics in affected and unaffected sides at self-selected walking speeds. **C.** Hip kinematics in affected sides at self-selected and 10% increased walking speeds. Blue lines represent the side that underwent THA and red lines represent the contralateral side. Gray bars along the x-rays indicate times points of significant differences between sides.