CLINICAL GAIT ANALYSIS IN PATIENTS FOLLOWING TOTAL HIP RESURFACING: EFFECT OF SURGICAL APPROACH ON BIOMECHANICAL BEHAVIOUR

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SUMMARY
Gait aberrations following hip replacements are associated with impaired functional outcomes and impaired loading of the implant. Gait analysis can provide a detailed evaluation of these aberrations that can be associated with the utilized surgical approach. The >1 year effect of 2 commonly utilized surgical approaches on the biomechanical behavior of hip resurfacings was compared with 3D gait analysis of overground walking, stair descent/ascend and unipodal stance. Patients following a direct lateral approach demonstrated a persistent abductor muscle weakness in comparison to the posterolateral approach cohort. However, gait analysis protocols should be extended to more strenuous tasks than only overground walking to highlight these gait abnormalities.

INTRODUCTION
Hip arthroplasty is a well-established procedure to treat end-stage osteoarthritis (OA) of the hip joint [1]. The success of hip resurfacing arthroplasty (SRA) is influenced by a multifaceted interaction of patient characteristics (e.g. age, gender, bone quality and activity level) and surgical-related parameters (e.g. approach, component fixation). Surgical approach is one of the parameters that have been found to strongly influence post-operative recovery following total hip replacement [2-4]. Different muscles are being damaged in the direct lateral (i.e. the gluteus medius) and the posterolateral (i.e. the short external rotators). As a result, both approaches hamper hip function recovery differently. However, literature is scarce about the effects on the biomechanical behavior following SRA.

The purpose of our study was to compare the effect of the direct lateral and a posterolateral approach in SRA on gait kinematics and kinetics as demonstrated with level walking and more strenuous gait-related tasks (i.e. stair ascent, stair descent).

METHODS
A total of fifteen patients who underwent unilateral hip resurfacing (SRA) were retrospectively selected from a cohort of 30 hip arthroplasty patients who performed three dimensional gait analysis. The inclusion criteria were a BMI <30 kg/m and an absence of hip osteoarthritis on the contralateral side. Eight patients with a mean age of 53 years underwent a Birmingham hip resurfacing (Smith & Nephew) utilizing a posterolateral approach (BMI: 26.1±2.04). Seven patients with a mean age of 46 years underwent a Durom hip resurfacing (Zimmer) conducted through the direct lateral approach (BMI: 26.5±3.7). The patients were recruited from practices of two different experienced hip replacement surgeons.

All patients had performed a 3D gait analysis after a minimum post-operative period of 12 months (26.6±11.3 months) and completion of their rehabilitation program. They were fitted with 22 passive reflective markers (14-mm) located on the lower limbs, pelvis, and trunk (Total body Plug-in-Gait marker set [5-7] with Knee Alignment Device, KAD [8], Vicon, Oxford, UK). Three-dimensional motion analysis was performed using an optical data capturing system (Vicon Motion Systems, UK) with 10 cameras, which determined the 3D trajectories of the markers. Data were collected at 100Hz. Ground reaction force, synchronized with the motion capture system, was also collected at 1000 Hz from two force plates (AMTI, Watertown, MA, USA) for gait cycle definition. All patients performed three trials of overground (level) walking (NW) at a self-selected pace for each limb. Five patients from the posterolateral cohort and 4 from the anterolateral cohort also performed stair ascent/descent (SA/SD) and unipodal stance (US). All data analyses were performed on both legs, allowing for comparison between the operated limb and sound limb.

Marker coordinate data were filtered using Woltring’s generalized cross-validation quintic smoothing spline with a predicted mean-square error of 15 mm [9]. Joint kinematics and kinetics of the ankle, knee, hip joints and trunk (kinematics only) were calculated and computed with commercially available software (Vicon Motion Systems, UK). Analyses focused on the stance phase of the gait cycle. Internal joint moments and ground reaction force (GRF) were normalized to body weight and to a 0-100% time cycle. Peak magnitude of the vertical GRF (GRFz_peak) during stance phase was identified and compared. Also, symmetry index was calculated and compared for GRFz_peak as previously described [10]. More positive and negative values would indicate a greater asymmetry towards the involved and uninvolved limb, respectively. All analyses were performed for one trial, selected from GRFz_peak. Data comparison between groups was performed using Mann Whitney U-Test. Significant threshold was set at α = 0.05.

RESULTS AND DISCUSSION
Similar joint kinematics, for the operated limb as well the sound limb, were found in both groups in every testing
condition except for stair descent. Patients in the direct lateral cohort exhibited at the beginning of the stance phase during stair descent more hip abduction for their operated side compared to patients in the posterolateral cohort. However, this was not significantly different. Also, more trunk flexion in the coronal plane and less knee flexion were observed for direct lateral patients during stair descent on their affected side.

Joint kinetics were also similar for both groups, except for stair descent. An important, but not significant (p=0.063) decrease of internal hip abduction moment was observed in direct lateral patients.

Among testing conditions, stair descent is the one for which patients exhibited higher GRFz_peak of up to 174% and 182% of body weight for patients in the posterolateral and direct lateral cohort, respectively. While group differences were not seen for GRFz_peak symmetry index during level walking, unipodal stance and stair ascent, the direct lateral group demonstrated a significant greater asymmetry during stair descent (p=0.031), (Figure 1).

![Figure 1: Symmetry index of peak vertical ground reaction force during level walking (NW), unipodal stance (US), stair ascent (SA) and stair descent (SD). Black: posterolateral approach cohort; grey: direct lateral approach cohort; p level=0.05.](image)

Foucher et al. [11], have demonstrated that pre-operative gait adaptations persist one year after total hip arthroplasty and that gait of these patients does not return to normal. This finding was supported in our study, which evaluated patients with a hip resurfacing. However, persistent deficits were only detected by including more strenuous gait-related tasks such as stair descent in the gait analysis protocol.

The most important limitations of our study are that we have a small sample size and we did not compare the gait analytical data with control subjects or with pre-operative values. However, the main purpose of this study was to compare the biomechanical effects and recovery at >1 year following 2 commonly used surgical approaches in hip resurfacing. It was expected that direct lateral approach patients would reveal an asymmetric gait pattern with a higher GRFz_peak and lower joint moments because of persistent abductor muscle weakness induced by the violation of the anterior and middle third of the gluteus medius muscle. While both groups did not demonstrate significant different joint kinematics and kinetics during level walking, unipodal stance, and stair ascent, the direct lateral group exhibited a distorted gait pattern during stair descent. A trend of greater operated limb GRFz_peak was evident compared to the sound limb, as demonstrated by a high positive asymmetry index. Moreover, a lower internal hip abduction moment was found during stair descent. Such findings highlight a residual abductor mechanism weakness following the direct lateral approach during stair descent. The increased amplitude of trunk lateroflexion on the operated side is suspected to be a compensatory mechanism to these weaker abductor muscles.

**CONCLUSIONS**

Weakness of the anterior and middle part of the gluteus medius persists in hip resurfacing patients following a direct lateral approach even after >1 year following the surgery. This can be associated with impaired joint loading. Post-operative rehabilitation should therefore emphasize more on muscle strengthening following the direct lateral approach.

Study protocols of gait analyses comparing the long term effects of surgical approach on gait recovery should include level walking but also more strenuous gait-related tasks such as stair descent.

**REFERENCES**