# Comparing hip muscle quality in fully-recovered transfemoral osseointegrated patients with healthy controls and patients with advanced hip osteoarthritis

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**INTRODUCTION:** While conventional prosthetics are the norm for many transfemoral amputees, a more recent option—the osseointegration of the prosthetic into the femur—offers an alternative for those that struggle with fit, comfort, and biomechanical function while using the traditional option [1]. Osseointegration is a two-stage surgery that takes place over a year and may lead to poor hip muscle quality from prolonged inactivity of the affected limb and imped effective biomechanical recovery. Currently, patients are commonly assessed using biomechanical measures such as gait [2]. In this study we aimed to understand the value in analyzing patient muscle quality and joint degeneration. To assess hip muscle quality, we compared hip muscle cross-sectional area (tCSA) and fat fraction (FF) (Gluteus medius, GMed; Gluteus minimus, GMin; and Tensor Fascia Latae, TFL) in post-operative transfemoral ossteointegrated (OS) patients with healthy controls and pre-operative total hip arthroplasty (THA) patients who have advanced hip osteoarthritis. Scoring Hip Osteoarthritis with Magnetic Resonance Imaging (SHOMRI) was used to assess hip joint degenerative changes. We wanted to understand where the affected hip muscles and joints of OS patients fell between those that are healthy and those suffering with advanced hip degeneration. We hypothesized that hip muscle quality would be compromised in the affected limbs of OS patients, but not directly relate to hip OA, inferring a result of the prolonged unloading and inactivity. Results from this study may support assessing hip muscle health and focused rehab efforts targeting hip muscles for improved biomechanical recovery following OS.

**METHODS:** With IRB approval and informed consent, a total of 24 scans were performed on 3 OS patients, 10 pre-operative THA patients, and 11 healthy control patients using a GE Discovery MR750 scanner with IDEAL (Iterative Decomposition of water and fat with Echo Asymmetry and Least-Squares Estimation) sequences. Manual segmentation of both the left and right GMed, GMin, and TFL were performed for each of the 24 axial slices using IPP (v6p43) on MatLab (see Figure 1(a)). FF and tCSA (mm2) for each muscle were calculated for each slice using a built-in tool in IPP on MatLab. SHOMRI scoring was performed by a musculoskeletal radiologist with 9 years of experience [3]. SHOMRI scores are divided into 5 individual domains (ex. SHOMRI-cartilage and SHOMRI-bone marrow); however, due to the abbreviated nature of this analysis, total SHOMRI scores (0-96) were used. Multiple statistical tests were used to assess the significance of our findings. A paired t-test was used to find a significant difference in the FF and tCSA per slice, and total SHOMRI score between the affected and unaffected hips of both the OS and THA cohorts, and between hips for the controls (see Figure 1(b)). A one-way ANOVA test was used to test the significance between cohorts for the per-patient average absolute difference in FF, the percent change in the per-patient average of tCSA, and the absolute difference in SHOMRI score between legs. Post-hoc Tukey's HSD test was used for a cohort-wise comparison of the same statistics tested using one-way ANOVA. Lastly, a linear regression model was used to test the significance of the correlation between the SHOMRI score and FF of the affected leg for the patient cohorts or bilateral average for the control cohort.

**RESULTS:** We examined differences between populations based on the affected hip alone and based on asymmetry between affected and unaffected hips. SHOMRI score were significantly different for the affected hip between THA and OS cohort (THA: 36.1±12.0, OS: 4.7±0.47, p=0.000002), and THA and controls (controls: 5.2±3.1, p<0.0001), but not between OS and controls (p=0.94). Muscle FF was significantly different for the affected hip in all three muscles between THA (GMed: 14.3±6.5, GMin: 19.6±10.1, TFL: 12.8±7.0) and controls (GMed: 6.3±2.7, GMin: 9.1±7.3, TFL: 6.3±4.1, p=0.002, 0.001, 0.002), and for GMin between OS (GMed: 11.5±7.1, GMin: 9.8±7.2, TFL: 9.5±7.6) and THA (p=0.04). There was no significant difference in average tCSA in the affected hip between any cohorts.

SHOMRI scores were significantly different between affected and unaffected hip in THA (95% diff, p=0.03), but not for the OS (62% diff, p=0.42). Controls did not have a significant asymmetry in SHMORI scores (65% diff, p=0.08). For muscle tCSA, we found significant asymmetry for GMin (15% diff, p=0.003) and TFL (42% diff, p=0.00007) for the THA cohort, and in all three muscles in the OS cohort (GMed: 36% diff, p<0.00001; GMin: 35% diff, p=0.02, TFL: 45% diff, 0.04). For muscle FF, we found significant asymmetry for GMed (4% diff, p=<0.00001) and GMin (6.8% diff, p<0.00001) for the THA cohort, and in GMed (6.1% diff, p<0.00001) and TFL (5.7% diff, p=0.001) for the OS cohort. Significance within the controls was found for GMed (tCSA: 11% diff, p<0.00001, FF: 1.3% diff, p=0.001) and GMin (tCSA: 14% diff, p=0.01, FF: 3.1% diff, p=0.0007), albeit with much lower differences compared to THA and OS cohorts. Linear regression showed a significant correlation in the affected SHOMRI score and muscle FF (p=0.024) in the THA cohort, but not in the OS or control cohort.

**DISCUSSION:** Our results indicate that hip muscle quality is compromised in the affected hip following osseointegration but is not necessarily related to hip OA. This may support that hip muscle quality is affected by the prolonged inactivity during the two-stage yearlong surgery and long recovery to full loadbearing. Hip quality is similarly compromised in the affected hip for THA patients, but additionally exhibited correlation to hip OA. Our study is limited because of the small sample size of OS patients. Next steps involve increasing OS sample size and comparing muscle quality results with biomechanical function.

**SIGNIFICANCE:** This study seeks to explore the potential importance of hip muscle quality following prolonged unloading from lower limb OS surgeries and recovery. OS is considered to have a biomechanical advantage over traditional prosthetic use, but potentially compromising effects on hip muscle health may impede biomechanical recovery, and there may be a need for assessing hip muscle health and providing specialized rehabilitation approaches for improved recovery following OS.

**REFERENCES**: [1] Zaid et al. 2019 (PMID: 31181031), [2] Halvorson et al. 2022 (PMID: 36812556), [3] Lee et al. 2014 (PMID: 25139720)

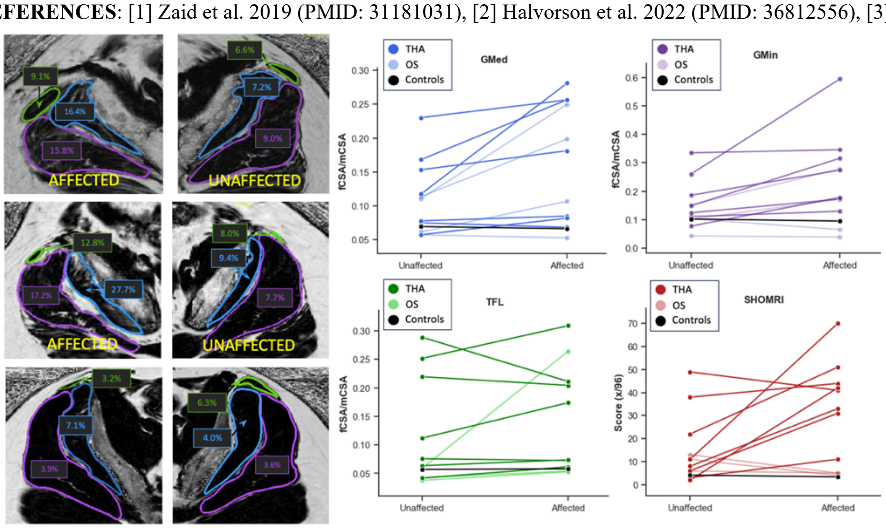


**Figure 1(a)** Visual representation of segmentations and FF for each cohort. The muscles are represented by the following colors: GMed as purple, GMin as blue, and TFL as green. **Figure 1(b)** Plots of the ratio of fCSA to mCSA and the total SHOMRI score from the unaffected to affected leg for each subject in the THA and OS cohort. The controls are represented as the ratio of the average fCSA to the average muscle CSA (mCSA) and the average total SHOMRI score.