

Preoperative Gluteal Muscle Volume and Quality as Predictors of Functional Recovery After Total Hip Arthroplasty: A 3D CT-Based Analysis

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Introduction

Total hip arthroplasty (THA) is an effective treatment for hip osteoarthritis, providing pain relief and improving range of motion and walking ability. However, postoperative functional recovery depends on each patient condition before surgery. Recently, attention has focused on preoperative muscle volume and computed tomography (CT)-derived Hounsfield units (HU), which correlate with intramuscular fat content; lower HU values indicate greater fatty infiltration (1, 2). Several investigators reported in hip disorders, atrophy and fatty degeneration of the hip abductor muscles, such as the gluteus medius and minimus (3). This current study aimed to investigate the influence of preoperative body weight-adjusted volume and HU values of the gluteus muscles automatically segmented from CT images—on longitudinal changes in postoperative functional scores, including the Japanese Orthopaedic Association (JOA) score and Harris Hip Score (HHS), compared with discharge values.

Methods

We included 56 patients who underwent primary THA at the Shonan Kamakura Joint Reconstruction Center between 2020 and 2023, who had preoperative CT scans acquired under the ZedHip protocol (LEXI, Japan), and had postoperative follow-up data. Postoperative improvements in the Japanese Orthopaedic Association (JOA) score and Harris Hip Score (HHS) were recorded at 2 months, 6 months, 1 year, and 2 years, using discharge (postoperative day 5) as the baseline. Preoperative muscle segmentation was performed using TotalSegmentator (Figure 1), a deep learning-based open-source model for medical image segmentation, running on 3D Slicer (an open-source medical imaging analysis platform). From pelvic to proximal femur CT data, the bilateral gluteus maximus, gluteus medius, and gluteus minimus were automatically segmented, and each muscle was classified as operated side or contralateral side. For each muscle, body weight-adjusted volume (cm^3/kg) was calculated by dividing the segmented volume (cm^3) by patient body weight (kg). Mean Hounsfield unit (HU) values were also computed for each muscle. Statistical analyses were performed using EZR (Jichi Medical University, Japan, version 2.13). Associations between preoperative muscle parameters and postoperative functional improvements were evaluated using Spearman's rank correlation coefficients, with delta JOA and delta HHS values (difference from discharge to each follow-up) as dependent variables.

Results

Preoperative operated-side gluteus medius HU values showed a significant positive correlation with HHS improvement from discharge at 1 year ($p = 0.0138$, $r = 0.431$) (Figure 2) and at 2 years ($p = 0.0376$, $r = 0.383$).

Preoperative contralateral gluteus maximus HU values were significantly positively correlated with JOA improvement from discharge at 6 months ($p = 0.0254$, $r = 0.299$), at 1 year ($p = 0.0163$, $r = 0.325$), and with HHS improvement from discharge at 1 year ($p = 0.0271$, $r = 0.391$) (Figure 3).

Preoperative contralateral gluteus maximus volume (adjusted for body weight) showed a significant positive association with JOA improvement from discharge at 2 years ($p = 0.0471$, $r = 0.271$).

In contrast, preoperative operated-side gluteus maximus volume (adjusted for body weight) was significantly negatively correlated with HHS improvement from discharge at 1 year ($p = 0.0141$, $r = -0.332$).

Discussion

This study suggests that HU values may serve as a more consistent predictor of postoperative recovery than muscle volume alone (1). The operated-side gluteus medius HU was particularly important for long-term functional improvement, likely reflecting its key role in pelvic stability during gait. Interestingly, contralateral gluteus maximus HU also correlated with outcomes, indicating the potential contribution of the non-operated limb's load-bearing and compensatory function during early rehabilitation (3). The negative correlation between operated-side gluteus maximus volume and 1-year HHS improvement implies that larger preoperative muscle volume does not necessarily indicate better function. These findings support the clinical relevance of qualitative assessment (HU) over quantitative volume alone.

Conclusion

Preoperative HU values of the gluteus medius and contralateral gluteus maximus are significant predictors of functional recovery after THA. Incorporating muscle quality assessment into preoperative planning could enhance prognostic accuracy and inform individualized rehabilitation strategies. Future prospective studies with larger sample sizes and multi-institutional data will be needed to validate these findings and assess their generalizability.



Figure 1. Preoperative 3D segmentation of gluteal muscles using TotalSegmentator.

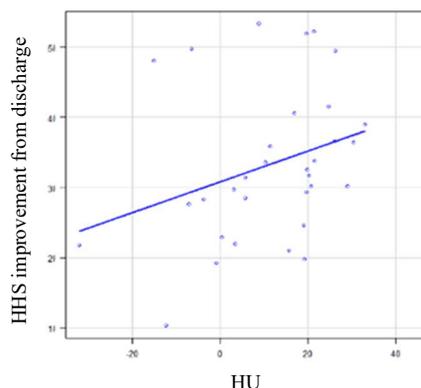


Figure 2. Positive correlation between preoperative operated-side gluteus medius HU and HHS improvement at 1 year from discharge ($p = 0.0138$, $r = 0.431$).

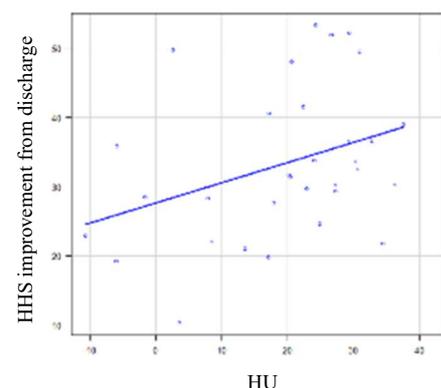


Figure 3. Positive correlation between preoperative contralateral gluteus maximus HU and HHS improvement at 1 year from discharge ($p = 0.0271$, $r = 0.391$).

References

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