Preoperative CT-Based Pelvic Sarcopenia and Subcutaneous Adiposity Predict Anaemia and Operative Time in Acetabular Fracture Surgery: A Retrospective Cohort Study

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Posted Date: 6 May 2026

doi: 10.20944/preprints202605.0333.v1

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Article

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Abstract

Background and Objectives: Acetabular fracture surgery is associated with substantial perioperative blood loss and prolonged operative time. Routine preoperative pelvic computed tomography (CT) carries information about body composition that is not currently exploited for risk stratification. We tested whether (i) CT-defined pelvic sarcopenia is associated with lower preoperative haemoglobin and a greater perioperative haemoglobin drop, and (ii) preoperative subcutaneous fat cross-sectional area (CSA) independently predicts operative time, after adjustment for surgical approach, age, fracture complexity and sarcopenia status. **Materials and Methods:** In this single-centre retrospective cohort study, 48 adults (37 men, 11 women; mean age 40.2 ± 16.5 years) who underwent open reduction and internal fixation (ORIF) for unilateral acetabular fractures between 2016 and 2024 were included. Pelvic muscle and subcutaneous fat CSAs were measured on the contralateral side of preoperative CT images using ImageJ. Sarcopenia was defined a priori as a sex-specific bottom tertile of psoas CSA. Group comparisons used Welch's t-test or Mann–Whitney U; correlations used Pearson's r; the multivariable model used ordinary least squares regression. A sensitivity power analysis was performed for all primary tests. **Results:** Sarcopenic patients (n = 17) had significantly lower preoperative haemoglobin (12.63 ± 1.24 vs. 14.00 ± 1.53 g/dL; mean difference −1.37 g/dL, 95% CI −2.20 to −0.55; p = 0.002; Cohen's d = 0.96) and a greater perioperative haemoglobin drop (ΔHb 1.64 ± 0.91 vs. 2.46 ± 1.87 g/dL; p = 0.046; d = 0.52) compared with non-sarcopenic patients (n = 31). Psoas, iliacus, gluteus medius–minimus and total muscle CSAs all correlated positively with preoperative haemoglobin (r = 0.42 to 0.49; all p ≤ 0.003). In the multivariable model (overall F[6, 41] = 3.71, p = 0.005; adjusted R^2 = 0.26), subcutaneous fat CSA (B = +0.25 min/cm², 95% CI +0.09 to +0.41, p = 0.004) and the modified Stoppa approach (vs. Kocher–Langenbeck; +65 min, p = 0.001) independently predicted operative time, while age, fracture complexity and sarcopenia did not. **Conclusions:** Routine preoperative pelvic CT in acetabular fracture patients can be repurposed as a one-stop opportunistic screen for two clinically actionable phenotypes: pelvic sarcopenia, which flags lower

 doi:10.20944/preprints202605.0333.v1

haematopoietic reserve and a greater perioperative haemoglobin drop, and elevated subcutaneous adiposity, which independently predicts longer operative time. Both findings can be obtained at zero marginal cost or radiation burden and could inform preoperative blood-product preparation, prehabilitation triage, and operating-room scheduling.

Keywords: acetabular fracture; sarcopenia; subcutaneous adipose tissue; cross-sectional area; opportunistic CT screening; operative time; haemoglobin; orthopaedic trauma

1. Introduction

Acetabular fractures are among the most demanding injuries in orthopaedic trauma surgery. Most are caused by high-energy mechanisms, frequently in patients with concomitant injuries, and surgical reconstruction often demands long operative times, anatomically deep dissection, and considerable intraoperative blood loss [1–4]. The pelvic ring is highly vascular, and uncontrolled haemorrhage remains a leading cause of perioperative morbidity and mortality; transfusion requirement, length of hospital stay, and operative duration each contribute meaningfully to overall outcome [5–8].

Risk stratification before acetabular fracture surgery currently relies on a small set of variables: age, fracture pattern, mechanism of injury, body mass index, and preoperative laboratory values, principally haemoglobin (Hb). Yet every patient who reaches the operating room for acetabular ORIF has already had a preoperative pelvic computed tomography (CT) scan for surgical planning. That image contains a great deal of information about the patient's body composition that is presently discarded: the cross-sectional areas (CSAs) of pelvic skeletal muscles, the radiodensity of those muscles, and the thickness of subcutaneous adipose tissue [9–13].

Two strands of literature support the value of extracting these parameters. First, low psoas CSA on abdominopelvic CT is now an accepted opportunistic surrogate for sarcopenia and has been linked to postoperative complications, prolonged length of stay, and mortality across general surgical, hip-fracture, and trauma populations [10,12,13,26]. Wang and colleagues, in a prospective hip-fracture cohort, showed that low muscle size and density are independently associated with mortality [12]. Nishimura and colleagues showed that the psoas muscle index predicts mortality and morbidity in geriatric trauma patients [26]. Second, in pelvic and acetabular trauma, body habitus and local soft-tissue thickness are known to influence operative complexity, but the literature has chiefly relied on body mass index — a composite measure that aggregates muscle, visceral adiposity, and subcutaneous adiposity into a single value and obscures their individual contributions [7,8,19]. CT-based, anatomically specific measurements offer a more direct mechanical correlate.

The clinical use case is concrete. If a CT-derived sarcopenia signal can be obtained for the price of a few minutes of segmentation, it could alert the surgical team to patients with reduced haematopoietic reserve who may benefit from earlier blood product preparation, antifibrinolytic prophylaxis, or prehabilitation triage. If subcutaneous fat CSA — independent of body mass index — predicts longer operative time, it could inform operating-room scheduling and theatre planning. To our knowledge no published study has addressed both questions in a single acetabular fracture cohort with formal multivariable adjustment.

This study therefore tested two specific, prespecified hypotheses in a retrospective cohort of patients undergoing ORIF for unilateral acetabular fractures. First, that pelvic sarcopenia, defined as a sex-specific bottom-tertile psoas CSA, would be associated with lower preoperative haemoglobin and a greater perioperative haemoglobin drop. Second, that preoperative subcutaneous fat CSA would independently predict operative time, after adjustment for surgical approach, age, fracture complexity, and sarcopenia status.

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2. Materials and Methods

2.1. Study Design and Participants

This single-centre retrospective cohort study was conducted at a tertiary referral hospital. The hospital surgical record system was searched for all adult patients (≥ 18 years) who underwent ORIF for an acetabular fracture between January 2016 and December 2024. From an initial search yielding 76 patients, 48 met the inclusion criteria of (i) unilateral acetabular fracture, (ii) preoperative pelvic CT available in DICOM format, and (iii) complete intraoperative and perioperative records (operative time, anaesthesia chart, pre- and postoperative haemoglobin, transfusion log). Patients with bilateral acetabular fractures, pathological fractures, prior pelvic surgery on the contralateral side, or incomplete imaging or laboratory data were excluded. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the University of Health Sciences Kayseri City Training and Research Hospital Clinical Research Ethics Committee (approval date: 27 May 2025; approval number: 460). Informed consent was waived owing to the retrospective nature of the analysis.

2.2. Clinical and Demographic Data

Age, sex, mechanism of injury, length of hospital stay, length of intensive care unit (ICU) stay, presence and type of concomitant injuries (defined as polytrauma when any other anatomical region was injured), neurological deficit, and preoperative waiting time were extracted from the electronic medical record. Fractures were classified using the Letournel–Judet system from the operative report and preoperative CT, and were grouped into elementary (posterior wall, posterior column, anterior column, anterior wall, transverse) and complex/associated patterns (T-shaped, transverse with posterior wall, anterior column with posterior hemitransverse, both-column) for analysis. Surgical approach (Kocher–Langenbeck, modified Stoppa, ilioinguinal) was recorded as documented by the operating surgeon. Operative time was extracted from the anaesthesia record. Preoperative haemoglobin was the most recent value within 24 hours before surgery; postoperative haemoglobin was the value drawn on postoperative day 1. ΔHb was calculated as preoperative minus postoperative. Estimated total blood loss was recorded from the anaesthesia chart. Red-cell transfusion was recorded as the number of units of packed red blood cells administered between admission and 48 hours postoperatively.

2.3. CT-Based Body Composition Measurement

All measurements were performed on preoperative pelvic CT acquired on a 64-slice multidetector scanner (slice thickness 1 mm). To eliminate the effect of trauma-induced soft-tissue change, all measurements were taken on the contralateral (uninjured) hemipelvis. Manual segmentation was performed in ImageJ (version 1.54, National Institutes of Health, Bethesda, MD, USA). Cross-sectional areas (cm^2) were measured at standardised anatomical levels: psoas major and iliacus at the L4–L5 intervertebral level; gluteus maximus and gluteus medius–minimus at the level of the centre of the acetabulum; subcutaneous adipose tissue at the L5 vertebral level, measured between the skin and the lateral fascial border. Representative segmentations are illustrated in Figure 1. Muscle radiodensity was recorded in Hounsfield units (HU) as a surrogate of muscle quality. Segmentations were performed jointly by orthopaedic surgeons (KTO, FA, SY, MI, FO) and radiologists (Eİ, AK), with 30 randomly selected images re-segmented after a four-week washout for intra-rater reliability assessment, and 20 images independently segmented by a second observer for inter-rater reliability assessment. The intraclass correlation coefficient (ICC, two-way random, absolute agreement) for CSA measurements was 0.95, indicating excellent reliability.

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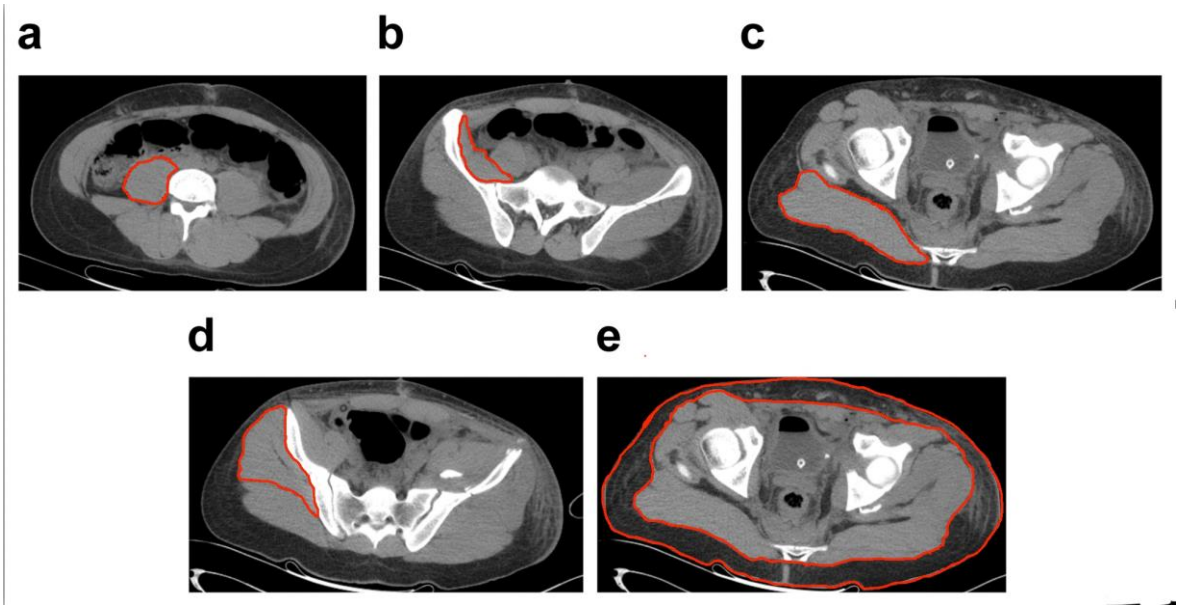

Figure 1. Representative manual segmentations of pelvic body composition parameters on the contralateral (uninjured) hemipelvis from preoperative pelvic CT. **(a)** Psoas major at the L4–L5 intervertebral level. **(b)** Iliacus at the L4–L5 intervertebral level. **(c)** Gluteus maximus at the level of the centre of the acetabulum. **(d)** Gluteus medius–minimus at the level of the centre of the acetabulum. **(e)** Subcutaneous adipose tissue at the L5 vertebral level, segmented between the skin surface and the lateral fascial border. Red outlines indicate the regions of interest used for cross-sectional area calculation in ImageJ.

2.4. Sarcopenia Definition

Because patient height was not consistently recorded in the trauma admission documentation, the height-normalised psoas muscle index could not be computed. Sarcopenia was instead defined a priori as a psoas CSA in the bottom tertile of the sex-specific distribution within the cohort, an approach used in earlier studies of CT-based sarcopenia where height was unavailable. Sex-specific cut-offs were 12.90 cm^2 for men and 8.08 cm^2 for women. As a sensitivity analysis, sarcopenia was redefined using a sex-specific median split (cut-offs 14.11 cm^2 for men and 8.20 cm^2 for women).

2.5. Statistical Analysis

Continuous variables are reported as mean ± standard deviation (SD) and categorical variables as count (percentage). Normality was assessed visually (Q–Q plots) and by the Shapiro–Wilk test. Between-group comparisons used Welch's t-test for normally distributed data and the Mann–Whitney U test otherwise; categorical variables were compared with Fisher's exact test. Effect sizes are reported as Cohen's d for continuous comparisons. Pairwise associations between body composition parameters and continuous perioperative outcomes were assessed with Pearson's correlation coefficient. Independent predictors of operative time were identified using ordinary least squares multivariable linear regression, with subcutaneous fat CSA, surgical approach (Kocher–Langenbeck as reference; modified Stoppa and ilioinguinal as indicators), age, fracture complexity (elementary as reference), and sarcopenia status as predictors. Body mass index could not be entered into the model as height was not consistently documented; this is acknowledged as a limitation. Variance inflation factors and Durbin–Watson statistics were used to assess multicollinearity and residual independence. A two-sided $p < 0.05$ was considered statistically significant.

As data collection had concluded at the time of analysis, an a priori sample size calculation was not appropriate. Instead, a sensitivity (post-hoc) power analysis was performed for the three principal tests, with two-sided $\alpha = 0.05$ and power = 0.80. With N = 48, the minimum detectable Pearson correlation was $|r| = 0.40$ (medium effect by Cohen's convention). For the multivariable regression with six predictors, the minimum detectable Cohen's f^2 was 0.31 (large effect). For the

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primary group comparison with the bottom-tertile sarcopenia definition (n = 17 vs. 31), the minimum detectable Cohen's d was 0.86. These thresholds are reported alongside the corresponding analyses to support interpretation of negative findings.

All analyses were performed in Python 3.12 using statsmodels (version 0.14), SciPy (version 1.13), and pandas (version 2.2).

3. Results

3.1. Cohort Characteristics

Of 48 included patients, 37 (77.1%) were men. The mean age was 40.2 ± 16.5 years (range 19–72). Mechanisms of injury were traffic accidents in 33 (68.8%) patients, falls from height in 14 (29.2%), and direct trauma in 1 (2.1%). Twenty patients (41.7%) had at least one concomitant injury (polytrauma), and 14 (29.2%) had a complex/associated fracture pattern. The Kocher–Langenbeck approach was used in 28 patients (58.3%), the modified Stoppa approach in 14 (29.2%), and the ilioinguinal approach in 6 (12.5%). Mean operative time was 155.5 ± 61.6 min and the mean estimated total blood loss was 1542.5 ± 862.5 mL. The mean preoperative Hb was 13.5 ± 1.6 g/dL, and the mean postoperative day-1 Hb was 11.4 ± 1.2 g/dL, giving a mean ΔHb of 2.2 ± 1.6 g/dL. The mean transfusion requirement was 1.7 ± 1.5 units of packed red cells. Cohort characteristics, overall and stratified by sarcopenia status, are summarised in Table 1.

Table 1. Cohort characteristics, overall and stratified by sarcopenia status.

Variable	Overall (n = 48)	Non-sarcopenic (n = 31)	Sarcopenic (n = 17)	p
Age (years)	40.2 ± 16.5	38.7 ± 17.6	43.1 ± 14.5	0.326
Male sex, n (%)	37 (77.1)	24 (77.4)	13 (76.5)	1.000
Polytrauma, n (%)	20 (41.7)	12 (38.7)	8 (47.1)	0.760
Complex fracture, n (%)	14 (29.2)	12 (38.7)	2 (11.8)	0.095
Surgical approach, n (%)				
Kocher–Langenbeck	28 (58.3)	20 (64.5)	8 (47.1)	0.522
Modified Stoppa	14 (29.2)	8 (25.8)	6 (35.3)	
Ilioinguinal	6 (12.5)	3 (9.7)	3 (17.6)	
Psoas CSA (cm²)	13.2 ± 3.9	15.0 ± 3.5	9.9 ± 2.4	<0.001
Total muscle CSA (cm²)	106.5 ± 19.0	110.8 ± 18.2	98.6 ± 18.3	0.033
Subcutaneous fat CSA (cm²)	178.7 ± 99.8	196.7 ± 106.0	146.0 ± 80.2	0.093

Values are mean ± SD or n (%). p-values from Welch's t-test or Mann–Whitney U for continuous variables and Fisher's exact test for categorical variables. Sarcopenia defined as sex-specific bottom-tertile psoas cross-sectional area. CSA: cross-sectional area.

3.2. Pelvic Sarcopenia Is Associated with Lower Preoperative Haemoglobin and a Greater Haemoglobin Drop

By the sex-specific bottom-tertile definition, 17 of 48 patients (35.4%) were classified as sarcopenic. Sarcopenic and non-sarcopenic groups did not differ significantly in age, sex distribution, polytrauma rate, fracture complexity, or surgical approach (Table 1). Sarcopenic patients had significantly lower preoperative haemoglobin (12.63 ± 1.24 vs. 14.00 ± 1.53 g/dL; mean difference −1.37 g/dL, 95% CI −2.20 to −0.55; t-test p = 0.002; Cohen's d = 0.96) and a smaller absolute perioperative haemoglobin drop (ΔHb 1.64 ± 0.91 vs. 2.46 ± 1.87 g/dL; p = 0.046; d = 0.52). The smaller drop in the sarcopenic group is consistent with starting at a lower baseline; postoperative day-1 haemoglobin was lower in sarcopenic patients (10.99 ± 1.09 vs. 11.54 ± 1.15 g/dL) but this difference did not reach significance (p = 0.110). Estimated total blood loss, transfusion requirement, operative time and ICU stay did not differ between groups (Table 2). Length of hospital stay was paradoxically shorter in the sarcopenic group (8.71 ± 4.48 vs. 11.97 ± 5.76 days; p = 0.017); given the lack of group differences in

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transfusion or operative time, this finding likely reflects unmeasured confounding from the higher rate of polytrauma-related extended admissions in the non-sarcopenic group rather than a benefit of sarcopenia, and is not interpreted further.

Table 2. Perioperative outcomes by sarcopenia status.

Outcome	Non-sarcopenic (n = 31)	Sarcopenic (n = 17)	Mean diff. (95% CI)	p
Preoperative haemoglobin (g/dL)	14.00 ± 1.53	12.63 ± 1.24	−1.37 (−2.20, −0.55)	0.002
Postoperative day-1 Hb (g/dL)	11.54 ± 1.15	10.99 ± 1.09	−0.55 (−1.23, +0.13)	0.110
Δ Haemoglobin (g/dL)	2.46 ± 1.87	1.64 ± 0.91	−0.83 (−1.64, −0.02)	0.046
Estimated total blood loss (mL)	1668.4 ± 960.1	1312.9 ± 608.5	−355.5 (−812.6, +101.7)	0.124
Transfusion (units of pRBC)	1.71 ± 1.49	1.65 ± 1.69	−0.06 (−1.06, +0.94)	0.567
Operative time (min)	160.5 ± 65.2	146.5 ± 55.1	−14.0 (−50.0, +22.0)	0.620
Hospital stay (days)	11.97 ± 5.76	8.71 ± 4.48	−3.26 (−6.29, −0.23)	0.017
ICU stay (days)	3.29 ± 4.22	1.82 ± 3.94	−1.47 (−3.94, +1.01)	0.104

Sarcopenia defined as sex-specific bottom-tertile psoas cross-sectional area. Mean differences are sarcopenic minus non-sarcopenic. Hb: haemoglobin; pRBC: packed red blood cells; ICU: intensive care unit.

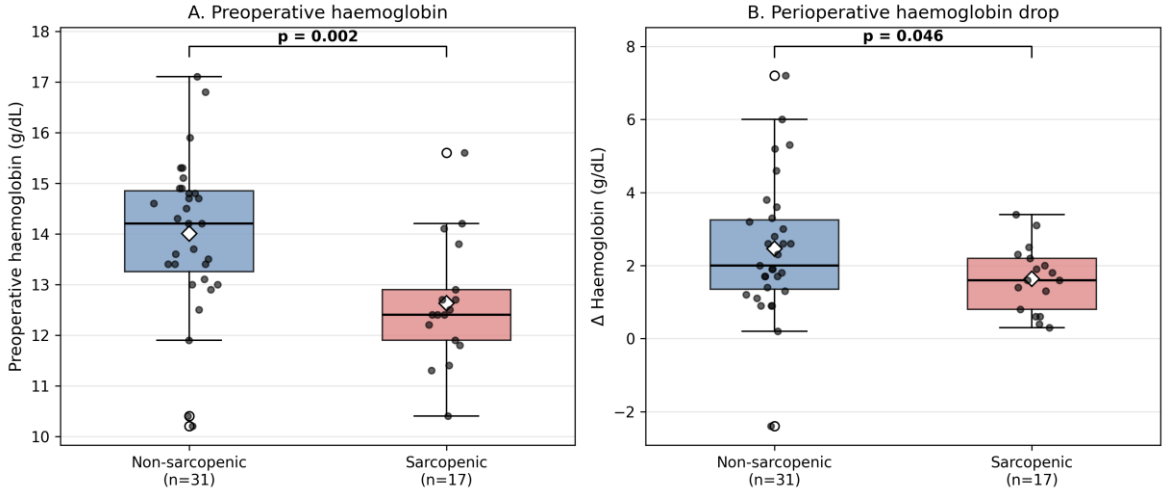

Figure 2. Preoperative haemoglobin and perioperative haemoglobin drop, by sarcopenia status. **(a)** Preoperative haemoglobin was significantly lower in sarcopenic patients (12.63 ± 1.24 vs. 14.00 ± 1.53 g/dL; p = 0.002). **(b)** Perioperative haemoglobin drop was smaller in sarcopenic patients (1.64 ± 0.91 vs. 2.46 ± 1.87 g/dL; p = 0.046), a pattern consistent with their lower starting haemoglobin. Boxes show median (line) and IQR; whiskers extend to 1.5× IQR; diamonds mark group means; individual data points are overlaid.

In the sensitivity analysis using a sex-specific median split (n = 22 sarcopenic vs. 26 non-sarcopenic), the direction and magnitude of the haemoglobin difference were preserved (preoperative Hb 12.93 ± 1.45 vs. 14.02 ± 1.51 g/dL; p = 0.015; d = 0.73), supporting the robustness of the primary finding to sarcopenia definition.

3.3. Body Composition Correlates with Preoperative Haemoglobin

Pelvic muscle CSAs and preoperative haemoglobin showed consistent positive correlations: psoas CSA (r = +0.489, p < 0.001), iliacus CSA (r = +0.417, p = 0.003), gluteus medius–minimus CSA (r = +0.436, p = 0.002), and total muscle CSA (r = +0.442, p = 0.002). Gluteus maximus CSA showed a smaller, non-significant correlation (r = +0.229, p = 0.119). Subcutaneous fat CSA was not correlated with preoperative haemoglobin (r = +0.160, p = 0.279) but was positively correlated with operative time (r = +0.371, p = 0.009). The full correlation matrix is provided in Table 3.

 doi:10.20944/preprints202605.0333.v1

Table 3. Pearson correlations between pelvic body composition parameters and perioperative outcomes (N = 48).

Body composition	Preop Hb	Postop Hb	ΔHb	Blood loss	Transfusion	Op. time
Psoas CSA	+0.489 ***	+0.210	+0.321 *	+0.176	−0.094	−0.085
Iliacus CSA	+0.417 **	+0.210	+0.253	+0.103	−0.124	+0.024
Gluteus med–min CSA	+0.436 **	+0.207	+0.273	+0.039	−0.234	+0.040
Gluteus maximus CSA	+0.229	+0.191	+0.085	−0.145	−0.293 *	−0.032
Total muscle CSA	+0.442 **	+0.246	+0.251	−0.002	−0.268	−0.014
Subcutaneous fat CSA	+0.160	−0.145	+0.255	+0.263	+0.098	+0.371 **

Significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Hb: haemoglobin; CSA: cross-sectional area.

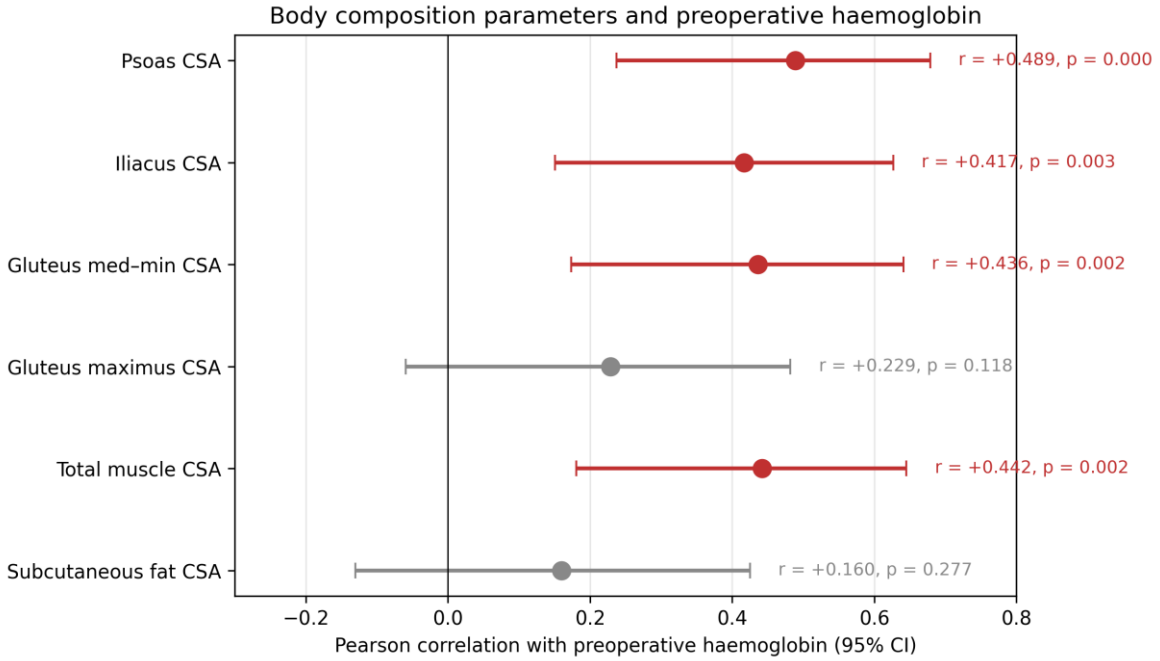

Figure 3. Pearson correlations between pelvic body composition parameters and preoperative haemoglobin, with 95% confidence intervals. Red bars indicate $p < 0.05$. All four pelvic muscle compartments showed positive correlations with preoperative haemoglobin; subcutaneous fat did not.

3.4. Subcutaneous Fat CSA Independently Predicts Operative Time

In the multivariable linear regression model for operative time (overall $F[6, 41] = 3.71$, $p = 0.005$; $R^2 = 0.352$; adjusted $R^2 = 0.257$; Durbin–Watson = 1.50; all variance inflation factors ≤ 1.26), two predictors reached significance. Each 1 cm² increase in subcutaneous fat CSA was associated with a 0.25 min increase in operative time (B = +0.250 min/cm², 95% CI +0.09 to +0.41; $p = 0.004$), independent of surgical approach, age, fracture complexity, and sarcopenia. The modified Stoppa approach was associated with operative time approximately 65 min longer than the Kocher–Langenbeck approach (B = +65.4 min, 95% CI +28.6 to +102.3; $p = 0.001$). The ilioinguinal approach did not differ significantly from Kocher–Langenbeck ($p = 0.667$). Age, fracture complexity, and sarcopenia status were not independent predictors of operative time. Full model results are presented in Table 4.

Table 4. Multivariable linear regression for operative time (N = 48).

Predictor	B	SE	95% CI	p
Subcutaneous fat CSA (per cm²)	+0.250	0.081	+0.09 to +0.41	0.004
Modified Stoppa (vs. Kocher–Langenbeck)	+65.43	18.24	+28.59 to +102.26	0.001
Ilioinguinal (vs. Kocher–Langenbeck)	+10.61	24.46	−38.79 to +60.01	0.667

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Age (per year)	−0.34	0.48	−1.32 to +0.63	0.481
Complex fracture (vs. elementary)	−21.36	18.33	−58.37 to +15.66	0.251
Sarcopenia (vs. non-sarcopenic)	−12.66	17.98	−48.96 to +23.65	0.485

Reference categories: Kocher–Langenbeck for surgical approach; elementary fracture; non-sarcopenic. Model fit: $F(6, 41) = 3.71$, $p = 0.005$; $R^2 = 0.352$; adjusted $R^2 = 0.257$. All variance inflation factors ≤ 1.26.

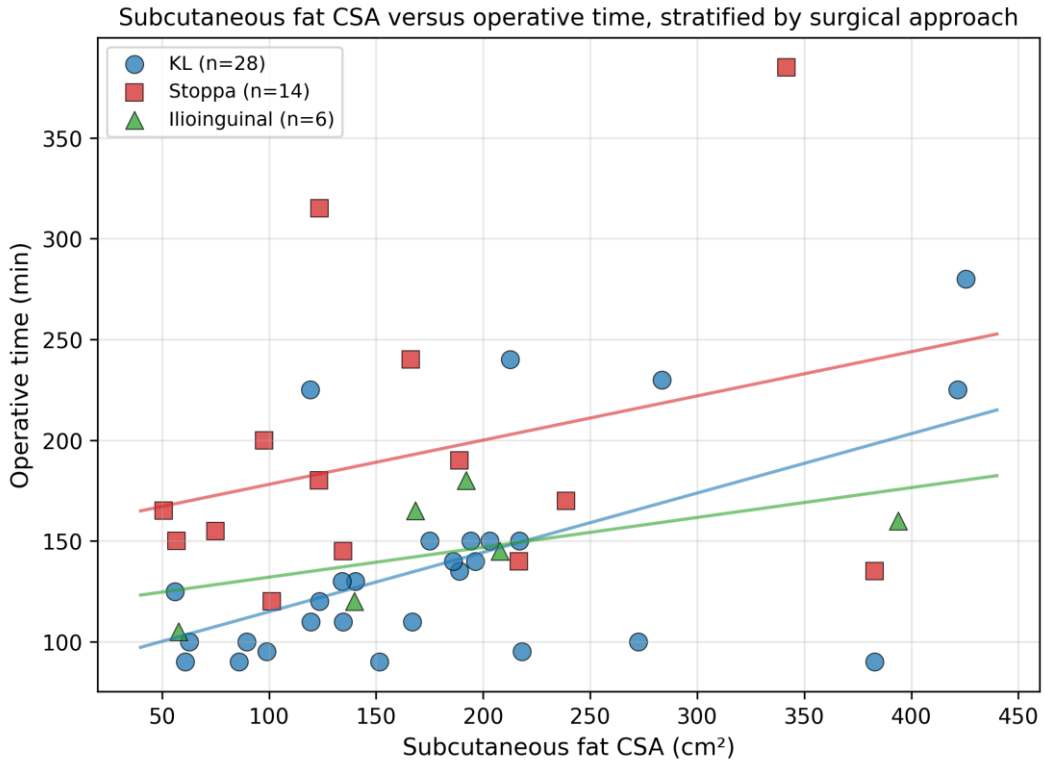

Figure 4. Subcutaneous fat cross-sectional area versus operative time, stratified by surgical approach. The positive slope is consistent across all three approaches; modified Stoppa procedures sit on a higher baseline operative time.

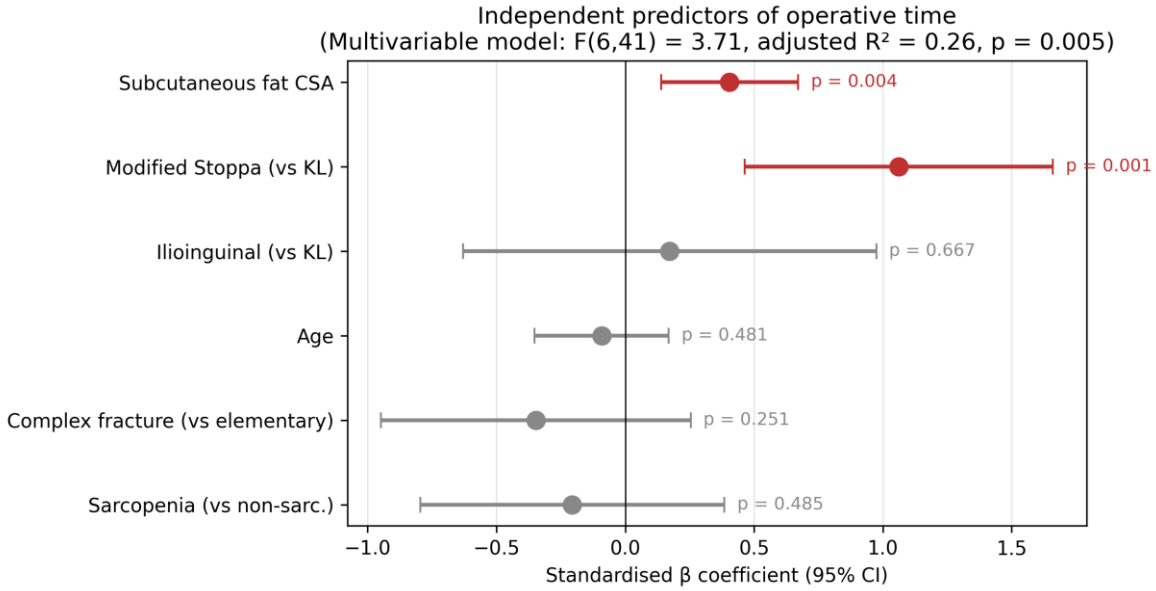

Figure 5. Forest plot of standardised regression coefficients (β) with 95% confidence intervals from the multivariable model for operative time. Red bars indicate $p < 0.05$. Subcutaneous fat CSA and the modified Stoppa approach were the only independent predictors.

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4. Discussion

In this retrospective cohort of 48 patients undergoing ORIF for unilateral acetabular fractures, two body-composition signals derived at no marginal cost from routine preoperative pelvic CT were associated with clinically distinct outcomes. First, pelvic sarcopenia — defined as a sex-specific bottom-tertile psoas CSA — was associated with markedly lower preoperative haemoglobin (mean difference 1.4 g/dL; Cohen's d = 0.96) and a smaller absolute perioperative haemoglobin drop, consistent with the lower starting baseline. Iliacus, gluteus medius–minimus, and total muscle CSAs showed concordant positive correlations with preoperative haemoglobin, supporting the construct validity of pelvic muscle CSA as a marker of haematopoietic reserve. Second, subcutaneous fat CSA independently predicted operative time after adjustment for surgical approach, age, fracture complexity, and sarcopenia status; each 1 cm^2 increase in fat CSA was associated with 0.25 min of additional operative time. The two findings are biologically and clinically distinct, and together suggest that a single preoperative pelvic CT can serve as an opportunistic, dual-purpose screen for risk stratification in acetabular fracture patients.

Our findings extend a growing literature on opportunistic CT-based sarcopenia assessment. Wang and colleagues, in 2023, reported that low muscle size and density were independently associated with mortality after hip fracture in a prospective cohort study [12]. Nishimura and colleagues, in geriatric trauma patients, identified the psoas muscle index as a predictor of both mortality and morbidity [26]. So and colleagues used psoas muscle volume on routine preoperative CT to diagnose sarcopenia in hip-fracture patients [13]. Jones and colleagues showed in colorectal surgery that simple psoas CSA measurement predicts major complications [10]. Our results are consistent with this body of work and add a specific dimension: in a younger acetabular trauma population (mean age 40 years), where overt geriatric sarcopenia is not the dominant clinical concern, sex-stratified relative sarcopenia still identifies a haematologically distinct phenotype. The clinical proposition is that psoas CSA measured from a pelvic CT obtained for surgical planning could serve as an early flag for the surgical and anaesthetic team — prompting earlier blood-product preparation, more deliberate consideration of antifibrinolytic prophylaxis, or more rigorous prehabilitation triage — rather than as a substitute for haemoglobin measurement, which is universal and inexpensive.

The independent association between subcutaneous fat CSA and operative time is consistent with prior observations that obesity influences operative complexity in pelvic and acetabular trauma surgery [7,8,19], and offers a refinement on those observations. Body mass index is a composite measure that aggregates muscle, visceral adiposity, and subcutaneous adiposity into a single value and obscures their distinct mechanical contributions. In acetabular surgery, the depth of subcutaneous tissue at the surgical site is the most direct contributor to access depth, retractor work, and wound closure time. CT-based subcutaneous fat CSA measures this directly and was an independent predictor of operative time even after adjustment for surgical approach — the strongest single contributor to operative time in our model and consistent with the published difference in operative duration between intrapelvic and posterior approaches [20–24]. Mullis and colleagues, in a randomised study of tranexamic acid and venous thromboembolism prophylaxis timing, showed that pharmacological measures alone did not reduce transfusion in anterior intrapelvic approach surgery [6]; this underscores the value of identifying anatomical, patient-level predictors. Weick and colleagues found that local subcutaneous fat thickness was not associated with postoperative infection in acetabular ORIF [7]; our findings suggest that the same parameter does, however, predict operative duration.

There are several limitations. First, the retrospective single-centre design limits generalisability and precludes adjustment for unmeasured confounders. Body mass index could not be included in the multivariable model because height was not consistently recorded in the trauma admission documentation; CT-based fat CSA may, however, be a more direct mechanical correlate of soft-tissue dissection depth than BMI. Surgeon-level factors (operator identity, level of training, intraoperative resuscitation decisions) could not be isolated. Second, the sample of 48 patients gave the study 80% power to detect Cohen's $d \geq 0.86$ for the primary group comparison, $|r| \geq 0.40$ for correlations, and

 doi:10.20944/preprints202605.0333.v1

Cohen's $f^2 \geq 0.31$ for the multivariable model; smaller effects, particularly between-group differences in transfusion requirement and reduction quality, cannot be reliably excluded, and the corresponding negative findings should be regarded as hypothesis-generating. Third, two-dimensional CSA at standardised slices was used as a surrogate for muscle and adipose mass; volumetric three-dimensional segmentation may yield more accurate phenotyping. Fourth, sarcopenia was defined relative to the cohort's sex-specific distribution rather than against an externally validated, height-normalised cut-off; future prospective studies that document height should re-test our findings using the height-normalised psoas muscle index. Fifth, mean cohort age was lower than is typical of the sarcopenia literature; whether the same magnitude of association is observed in a geriatric acetabular fracture population is unknown. Finally, while pelvic muscle quality has been linked with cognitive and functional outcomes in older patients [11,12], this study did not capture functional outcome measures.

The clinical implications are practical and immediate. In acetabular fracture patients planned for ORIF, the same preoperative pelvic CT obtained for surgical planning can be repurposed as a one-stop opportunistic screen: psoas CSA at the L4–L5 level identifies patients with low haematopoietic reserve who may benefit from more aggressive perioperative blood management; subcutaneous fat CSA at the L5 level identifies patients in whom operating-room scheduling should anticipate longer cases. Because the segmentation can be completed in under five minutes by a single trained observer with excellent reliability (ICC 0.95) and adds neither cost nor radiation exposure, the marginal effort is small relative to the clinical information returned. Validation in a larger, multicentre prospective cohort with prospectively recorded height — to enable standard, externally validated sarcopenia thresholds — and with functional outcome measures, is the natural next step.

5. Conclusions

Routine preoperative pelvic CT in acetabular fracture surgery contains two body-composition signals with distinct clinical relevance. Pelvic sarcopenia, defined as bottom-tertile psoas CSA, is associated with lower preoperative haemoglobin and a greater perioperative haemoglobin drop, and may serve as an opportunistic preoperative biomarker of haematopoietic and somatic reserve. Subcutaneous fat CSA independently predicts operative time, after adjustment for surgical approach, age, fracture complexity, and sarcopenia, offering a more direct mechanical correlate of operative complexity than body mass index. Both signals are extractable at no marginal cost or radiation burden from imaging that is already obtained for surgical planning, and could inform preoperative blood-product preparation, prehabilitation triage, and operating-room scheduling. Validation in a larger, multicentre prospective cohort is warranted.

Author Contributions: Conceptualisation, K.T.O. and S.Y.; methodology, K.T.O., F.A. and S.Y.; supervision, A.K. and F.O.; resources, F.A. and S.Y.; data curation, S.Y., E.İ. and M.İ.; formal analysis and interpretation, E.İ., M.İ., A.K. and F.O.; literature search, K.T.O., F.A. and S.Y.; writing—original draft preparation, K.T.O. and F.O.; writing—review and editing, A.K. and F.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and was approved by the University of Health Sciences Kayseri City Training and Research Hospital Clinical Research Ethics Committee (approval date: 27 May 2025; approval number: 460).

Informed Consent Statement: Patient consent was waived owing to the retrospective design of the study and the use of fully anonymised clinical and imaging data.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to institutional regulations.

 doi:10.20944/preprints202605.0333.v1

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CT Computed Tomography
CSA Cross-Sectional Area
Hb Haemoglobin
ICU Intensive Care Unit
ORIF Open Reduction and Internal Fixation
pRBC Packed Red Blood Cells
SD Standard Deviation
STROBE Strengthening the Reporting of Observational Studies in Epidemiology

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