

Is lateral ankle soft tissue thickness a risk factor for fracture-related infection in rotational ankle fractures? A retrospective review

Adam Schlauch

Denver Health Medical Center

Anna Zakusylo

Denver Health Medical Center

Brandi Kreig

Denver Health Medical Center

Jack Hop

Denver Health Medical Center

John Duldner

John.Duldner@dhha.org

Denver Health Medical Center

Cyril Mauffrey

Denver Health Medical Center

Justin Hellwinkel

Denver Health Medical Center

Nathaniel Schaffer

Denver Health Medical Center

Research Article

Keywords: ankle fracture, fracture-related infection, soft tissue, computed tomography

Posted Date: August 31st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10697671/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Purpose

To determine whether lateral ankle soft tissue thickness (LASTT) is associated with fracture-related infection (FRI) after open reduction and internal fixation (ORIF) of closed rotational ankle fractures.

Methods

This retrospective cohort included adults treated with ORIF for acute closed OTA/AO 44A-C ankle fractures at a single Level I trauma center from January 2019 to January 2025. Patients with less than 6 months of follow-up, no preoperative computed tomography, or open fractures were excluded. LASTT was the mean distance from the lateral fibular cortex to the dermal surface at the fibular tip, tibial plafond, and syndesmotic level. Associations with FRI were evaluated using logistic regression.

Results

Among 116 patients, 10 (8.6%) developed FRI. Mean LASTT was not associated with FRI as a continuous variable (odds ratio [OR] 1.1 per mm, 95% confidence interval [CI] 0.9–1.4; $p > 0.35$) or categorically. Compared with the standard group, the thin group had an OR of 0.81 (95% CI 0.11–3.6; $p > 0.79$) and the thick group an OR of 0.40 (95% CI 0.02–2.5; $p > 0.40$). Increasing age was independently associated with FRI (OR 2.3 per 15-year increase above the cohort mean age of 41 years, 95% CI 1.2–5.0; $p < 0.03$).

Conclusion

Preoperative LASTT was not associated with FRI after ORIF of closed rotational ankle fractures and should not be considered an independent predictor of FRI in this population.

INTRODUCTION

Rotational ankle fractures are among the most common injuries treated by orthopaedic surgeons [1]. One of the most common complications following surgery for rotational ankle fractures is fracture-related infection (FRI), which can occur in 1.4–16% of injuries and is more common in geriatric patients [2–4]. Need for additional surgeries following ankle open reduction and internal fixation (ORIF), including irrigation and debridement for FRI, is devastating to patients and costly to the medical system [2, 5]. Patient-related risk factors for FRI in ankle fractures include open fracture, diabetes, peripheral neuropathy, immunosuppression, smoking, congestive heart failure, peripheral vascular disease, and increased age [3, 6].

Since many patient-related risk factors at the time of injury are difficult or impossible to modify, especially in unstable fractures that necessitate surgical intervention, additional patient characteristics that may help identify patients at increased risk of infection based on pre-operative data are desirable. One such characteristic may be lateral ankle soft tissue thickness (LASTT), which can be readily measured on routine pre-operative CT imaging. Soft tissue thickness has been investigated as a potential risk factor for surgical site infection in other orthopaedic procedures, including spine surgery [7–11].

The purpose of this study was to determine whether lateral ankle soft tissue thickness (LASTT), measured on post-reduction, pre-operative ankle CT imaging, was associated with fracture-related infection following ORIF for closed rotational ankle fractures.

METHODS

Patient selection

A total of 248 adult patients who underwent open reduction and internal fixation (ORIF) for closed rotational ankle fractures (OTA/AO 44A, 44B, and 44C) at a single Level I academic trauma center between January 1, 2019 and January 1, 2025 were retrospectively identified using Current Procedural Terminology (CPT) codes 27822 (open treatment trimalleolar ankle fracture without fixation of posterior lip), 27823 (open treatment trimalleolar ankle fracture with fixation of posterior lip), 27792 (open treatment of distal fibular fracture, lateral malleolus), and 27814 (open treatment bimalleolar ankle fracture) [12].

Patients were excluded if they did not have an approach or fixation to the fibula, were younger than 18 years, lacked a pre-operative CT scan, were lost to follow-up before 6 months without radiographic union, underwent intramedullary fixation without open reduction, had prior ipsilateral ankle surgery, sustained an open fracture, underwent staged management with external fixation, had a non-ankle fracture, or did not undergo ORIF despite diagnosis. After applying these exclusion criteria, 116 patients remained for analysis.

Method of measurements and collected variables

Lateral ankle soft tissue thickness (LASTT) was measured on post-reduction, pre-operative ankle CT scans using standardized anatomic landmarks. Coronal and axial CT images were reviewed together to ensure accurate localization. Three axial levels along the distal fibula were identified on coronal CT images and confirmed on the corresponding axial images:

1. Fibular tip – distal tip of the lateral malleolus.
2. Tibial plafond – level of the ankle joint plafond.
3. Syndesmotomic level – 2 cm proximal to the tibial plafond.

At each level, soft tissue thickness was measured on the axial CT as the perpendicular distance from the lateral cortex of the fibula to the external dermal surface. Measurements were recorded in millimeters. Mean LASTT, calculated as the average of the three measurements, served as the primary exposure variable for all analyses.

Patient demographic and clinical variables collected included age, sex, body mass index (BMI), body weight, American Society of Anesthesiologists (ASA) classification, diabetes mellitus, active smoking status, alcohol use, immunosuppressive medication use, methamphetamine use, peripheral vascular disease, OTA/AO fracture classification, fracture pattern, surgical approach, wound closure method, and fibular fixation construct.

Outcome measure and groups compared

Fracture-related infection (FRI) was the primary outcome and was retrospectively diagnosed using the confirmatory criteria established by Metsemakers et al., defined as the presence of a sinus tract, fistula, or purulence [13].

The entire cohort was divided into thin (bottom 20% of mean LASTT), standard (middle 60% of mean LASTT), and thick (upper 20% of mean LASTT) groups.

The three groups were compared for the primary outcome of FRI. Multivariable analysis was performed to identify independent risk factors associated with FRI.

Statistical Analysis

Baseline characteristics were compared using Pearson's χ^2 test for categorical variables and one-way analysis of variance (ANOVA) for continuous variables. Logistic regression was used to evaluate the association between mean LASTT and fracture-related infection with thickness modeled both as a continuous variable and categorically (thin, standard, and thick). Models were adjusted for variables previously associated with infection, including age, BMI > 30 kg/m², ASA class > II, smoking status, peripheral vascular disease, and diabetes mellitus. Thickness measurements obtained at each anatomic level were compared with mean LASTT using linear regression. Statistical significance was defined as $p < 0.05$. All analyses were performed using R Statistical Software (version 4.5.2; R Core Team 2025) [14].

RESULTS

A total of 248 patients were identified for review. Patients were excluded because of loss to follow-up ($n = 58$), lack of pre-operative CT imaging ($n = 42$), intramedullary fixation without an open approach ($n = 7$), staged external fixation ($n = 7$), prior ipsilateral ankle surgery ($n = 2$), open fracture ($n = 15$), and non-ankle fracture ($n = 1$). After applying the exclusion criteria, 116 patients remained for analysis.

Overall, 10 patients (8.6%) developed FRI, all of whom underwent operative irrigation and debridement.

Patients who developed FRI were significantly older than those who did not (49.8 vs. 39.9 years, $p = 0.04$). There were no significant differences between patients with and without FRI with respect to mean LASTT, sex, BMI, ASA class, diabetes, smoking status, alcohol use, immunosuppression, methamphetamine use, peripheral vascular disease, OTA/AO classification, fracture pattern, surgical approach, wound closure method, or fixation construct.

Patients in the "thin" soft tissue thickness group had significantly lower body mass, but otherwise there were no significant differences in demographic, injury, or operative characteristics between groups (Table 1).

Table 1. Patient and Injury Characteristics Stratified by Mean Lateral Ankle Soft Tissue Thickness

Variable	Thin (n=24)	Standard (n=69)	Thick (n=23)	p- value ^a
Age — years (mean ± SD)	45.0 ± 16.4	40.1 ± 14.4	38.6 ± 12.9	0.27
Male sex — n (%)	10 (41.7)	31 (44.9)	11 (47.8)	0.91
BMI — kg/m ² (mean ± SD)	28.4 ± 5.2	31.8 ± 6.7	30.1 ± 7.5	0.09
Weight — kg (mean ± SD)	78.8 ± 16.7	90.0 ± 19.1	85.1 ± 18.2	0.04
ASA classification — n (%)				0.77
1	5 (20.8)	12 (17.4)	7 (30.4)	
2	15 (62.5)	46 (66.7)	13 (56.5)	
3	4 (16.7)	11 (15.9)	3 (13.0)	
Diabetes — n (%)	3 (12.5)	6 (8.7)	1 (4.3)	0.61
Smoking — n (%)	3 (12.5)	18 (26.1)	6 (26.1)	0.37
Alcohol use — n (%)	6 (25.0)	10 (14.5)	3 (13.0)	0.43
Immunosuppression use — n (%)	1 (4.2)	2 (2.9)	0 (0.0)	0.65
Methamphetamine use — n (%)	1 (4.2)	2 (2.9)	1 (4.3)	0.93
Peripheral vascular disease — n (%)	2 (8.3)	1 (1.4)	0 (0.0)	0.13
OTA/AO classification — n (%)				0.34
44A	3 (12.5)	16 (23.2)	2 (8.7)	
44B	14 (58.3)	41 (59.4)	17 (73.9)	
44C	7 (29.2)	12 (17.4)	4 (17.4)	
Posterolateral approach — n (%)	2 (8.3)	5 (7.2)	5 (21.7)	0.13
Closure — n (%)				0.57
Nylon	16 (66.7)	31 (44.9)	12 (52.2)	
Staples	1 (4.2)	8 (11.6)	2 (8.7)	
Subcuticular	6 (25.0)	28 (40.6)	9 (39.1)	
Nylon + staples	1 (4.2)	2 (2.9)	0 (0.0)	
Fibular fixation — n (%)				0.58
Direct lateral plate	20 (83.3)	59 (85.5)	18 (78.3)	

Variable	Thin (n=24)	Standard (n=69)	Thick (n=23)	p- value ^a
<i>frag plate</i>				
<i>Direct lateral plate, Anterior Mini-frag plate</i>	0 (0.0)	1 (1.4)	0 (0.0)	
<i>Mini-frag plate</i>				
<i>Direct lateral plate, Posterior Mini-frag plate</i>	2 (8.3)	1 (1.4)	0 (0.0)	
<i>plate</i>				
<i>Direct lateral plate, Posterolateral plate</i>	0 (0.0)	1 (1.4)	1 (4.3)	
<i>Direct posterior plate</i>	0 (0.0)	3 (4.3)	2 (8.7)	
<i>Posterolateral plate</i>	2 (8.3)	4 (5.8)	2 (8.7)	
Mean soft tissue thickness – mm (mean ± SD)	5.5 ± 1.2	9.6 ± 1.4	13.9 ± 1.1	<0.001

Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; OTA/AO, Orthopaedic Trauma Association/AO Foundation, SD, standard deviation.

☒ P values were calculated using one-way analysis of variance for continuous variables and Pearson chi-square test for categorical variables.

For subgroup analysis, 24 patients were categorized as thin (mean LASTT 5.5 ± 1.2 mm; mean age 45.0 ± 16.4 years; 41.7% male), 69 as standard (mean LASTT 9.6 ± 1.4 mm; mean age 40.1 ± 14.4 years; 44.9% male), and 23 as thick (mean LASTT 13.9 ± 1.1 mm; mean age 38.6 ± 12.9 years; 47.8% male) (Table 1).

Lateral Ankle Soft Tissue Thickness and Infection Risk

The mean LASTT was not different between patients with and without FRI (9.81 ± 2.47 mm vs. 9.75 ± 2.67 mm, $p = 0.94$). Thickness measurements at each anatomic level were strongly correlated with mean LASTT (all $p < 0.001$; $R^2 = 0.66$ – 0.86).

Logistic regression using mean LASTT as a continuous variable demonstrated no significant association with FRI (OR 1.1 per mm increase, 95% CI 0.9–1.4, $p > 0.35$).

Similarly, when analyzed categorically, patients with thin LASTT had an OR of 0.81 (95% CI 0.11–3.6, $p > 0.79$), and patients with thick LASTT had an OR of 0.40 (95% CI 0.02–2.5, $p > 0.40$), compared with the standard group (Table 2).

Table 2. Fracture-Related Infection Rates by Mean Lateral Ankle Soft Tissue Thickness Cohort

Soft Tissue Thickness Group	No FRI – n (%)	FRI – n (%)	P-value
Thin (n = 24)	22 (91.7)	2 (8.3)	0.691 ^a
Standard (n = 69)	62 (89.9)	7 (10.1)	
Thick (n = 23)	22 (95.7)	1 (4.3)	

Abbreviations: FRI, fracture-related infection.

✕ P value calculated using Pearson chi-square test.

Multivariate Analysis

On multivariable logistic regression adjusting for established risk factors for FRI (age, BMI >30 kg/m², ASA class >II, smoking, diabetes mellitus, and peripheral vascular disease), increasing age remained independently associated with FRI. Specifically, each 15-year increase above the cohort mean age of 41 years was associated with a 2.3-fold increase in the odds of FRI (95% CI 1.2–5.0, $p < 0.03$). Mean LASTT was not independently associated with FRI.

Discussion

This retrospective cohort study of patients with closed rotational ankle fractures treated with open reduction and internal fixation demonstrated that mean lateral ankle soft tissue thickness (LASTT) was not associated with fracture-related infection (FRI). Increased age remained independently associated with FRI, consistent with previous reports [2, 3]. Although the overall rate of FRI in this cohort (8.6%) was higher than that reported in some prior series, LASTT was not associated with fracture-related infection when analyzed as either a continuous or categorical variable.

Previous studies have identified several patient-related risk factors for FRI following operative ankle fractures, including diabetes, smoking, peripheral vascular disease, immunosuppression, and increasing age [3, 6]. Because these factors are largely nonmodifiable at the time of injury, investigators have also evaluated potentially modifiable factors that may reduce infection risk. Ovaska et al. investigated delayed antibiotic administration, operative duration, malreduction, cast application in the operating room, tourniquet use, syndesmotic screw fixation, surgeon experience, and wound closure method [15]. Multivariable analysis demonstrated that operative time greater than 90 minutes and cast application in the operating room were independently associated with infection [15].

Studies have also investigated whether soft tissue thickness measured on pre-operative imaging predicts postoperative complications in orthopaedic surgery. In total ankle arthroplasty, Wu et al. reported that increased anterior soft tissue thickness was associated with revision surgery but not infection [16]. Likewise, Kalma et al. found no association between anterior soft tissue thickness and postoperative infection following total ankle arthroplasty [17]. In contrast, Wu et al. demonstrated that

increased shoulder soft tissue thickness was associated with postoperative infection after reverse total shoulder arthroplasty [8].

Additionally, studies in spine surgery have consistently demonstrated an association between increased soft tissue thickness and surgical site infection. Gupta et al. reported that a spine adipose index of ≥ 0.51 cm was associated with a two-fold increased risk of deep surgical site infection following posterior lumbar fusion [10]. Similar findings were reported by AlSaleh et al [11], although soft tissue thickness was measured from the skin to the spinous process. These investigations, however, evaluated elective surgical populations, which differ substantially from patients undergoing operative fixation of acute traumatic ankle fractures.

The present study evaluated whether LASTT measured on pre-operative CT was associated with fracture-related infection following ORIF of closed rotational ankle fractures. No association was identified between LASTT and FRI, regardless of whether thickness was analyzed as a continuous variable or categorized into thin, standard, and thick groups. These findings suggest that pre-operative LASTT should not be considered an independent predictor of postoperative fracture-related infection in this patient population.

This study has several limitations. First, LASTT was measured on the injured extremity after trauma, making it difficult to distinguish native soft tissue thickness from acute injury-related swelling. Measurement of the contralateral uninjured ankle would likely have provided a more accurate estimate of baseline soft tissue thickness. Additionally, the time from injury to CT imaging was not evaluated, limiting interpretation of the contribution of post-injury swelling to the measurements obtained. Other limitations include the retrospective design, relatively small sample size, and institution-specific use of pre-operative CT imaging. Although the minimum six-month follow-up was sufficient to capture acute postoperative fracture-related infection, longer follow-up may have identified additional complications. Unlike prior studies, smoking and several medical comorbidities were not independently associated with FRI in this cohort. This difference may reflect the restriction of the present study to closed rotational ankle fractures, whereas previous investigations also included open injuries associated with higher-energy mechanisms [3, 6, 13].

Conclusions

Soft tissue thickness along the lateral ankle was not associated with fracture related infection in adult patients with closed rotational ankle fractures that were treated with open reduction and internal fixation. Surgeons should not necessarily alter their surgical decisions based on lateral ankle soft tissue thickness when considering risk of infection. Consideration of fixation strategies should still be given to patient related factors such as age when addressing these injuries.

Declarations

For this retrospective review, institutional review board approval was obtained prior to study initiation. Given the retrospective design of the study, the requirement for individual patient informed consent was formally waived by the reviewing ethics committee.

References

1. Scheer RC, Newman JM, Zhou JJ et al (2020) Ankle fracture epidemiology in the United States: patient-related trends and mechanisms of injury. *J Foot Ankle Surg* 59:479–483. <https://doi.org/10.1053/j.jfas.2019.09.016>
2. SooHoo NF, Krenke L, Eagan MJ, Gurbani B, Ko CY, Zingmond DS (2009) Complication rates following open reduction and internal fixation of ankle fractures. *J Bone Joint Surg Am* 91:1042–1049. <https://doi.org/10.2106/JBJS.H.00653>
3. Pilskog K, Høvdig P, Fenstad AM, Inderhaug E, Fevang JM, Dale H (2023) Risk factors for fracture-related infection after ankle fracture surgery. *Injury* 54:111011. <https://doi.org/10.1016/j.injury.2023.111011>
4. Spek RWA, Smeeing DPJ, van den Heuvel L et al (2021) Complications after surgical treatment of geriatric ankle fractures. *J Foot Ankle Surg* 60:712–717. <https://doi.org/10.1053/j.jfas.2019.12.012>
5. Naumann MG, Sigurdson U, Utvåg SE, Stavem K (2017) Functional outcomes following surgical-site infections after operative fixation of closed ankle fractures. *Foot Ankle Surg* 23:311–316. <https://doi.org/10.1016/j.fas.2016.10.002>
6. Miller AG, Margules A, Raikin SM (2012) Risk factors for wound complications after ankle fracture surgery. *J Bone Joint Surg Am* 94:2047–2052. <https://doi.org/10.2106/JBJS.K.01088>
7. Vahedi H, Ward DT, Lee YS, Shohat N, Chen AF (2020) Greater knee soft tissue thickness predisposes patients to subsequent periprosthetic joint infection after total knee arthroplasty. *J Arthroplasty* 35:1924–1927. <https://doi.org/10.1016/j.arth.2020.02.049>
8. Wu KA, Helmkamp J, Levin JM et al (2024) Association between radiographic soft-tissue thickness and increased length of stay, operative time, and infection rate after reverse shoulder arthroplasty. *J Shoulder Elb Surg* 33:1267–1275. <https://doi.org/10.1016/j.jse.2023.10.017>
9. Parikh S, Pannu TS, Davis T, Gomez O, Corces A (2023) Local soft-tissue thickness versus body mass index as predictors of complications after total knee or hip arthroplasty: a literature review. *JBJS Rev* 11(11). <https://doi.org/10.2106/JBJS.RVW.22.00128>
10. Gupta VK, Zhou Y, Manson JF, Watt JP (2021) Radiographic spine adipose index: an independent risk factor for deep surgical site infection after posterior instrumented lumbar fusion. *Spine J* 21:1711–1717. <https://doi.org/10.1016/j.spinee.2021.04.005>
11. AlSaleh K, Aldowesh A, Alqhtani M et al (2022) Subcutaneous fat thickness on erect radiographs is a predictor of infection following elective posterior lumbar fusion. *Int J Spine Surg* 16:660–665. <https://doi.org/10.14444/8295>

12. Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF (2018) Fracture and dislocation classification compendium-2018. *J Orthop Trauma* 32(Suppl 1):S1–S170.
<https://doi.org/10.1097/BOT.0000000000001063>
13. Metsemakers WJ, Morgenstern M, McNally MA et al (2018) Fracture-related infection: a consensus on definition from an international expert group. *Injury* 49:505–510.
<https://doi.org/10.1016/j.injury.2017.08.040>
14. R Core Team (2025) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. <https://www.R-project.org/>. Accessed 14 Aug 2026
15. Ovaska MT, Mäkinen TJ, Madanat R et al (2013) Risk factors for deep surgical site infection following operative treatment of ankle fractures. *J Bone Joint Surg Am* 95:348–353.
<https://doi.org/10.2106/JBJS.K.01672>
16. Wu KA, Anastasio AT, Krez AN et al (2024) Association of radiographic soft tissue thickness with revision total ankle arthroplasty following primary total ankle arthroplasty: a minimum of 5-year follow-up. *Foot Ankle Orthop* 9(2). <https://doi.org/10.1177/24730114241255351>
17. Kalma JJ, El-Zein ZS, Koueiter D, Fortin PT (2022) Soft tissue thickness as a predictor of wound complications after total ankle arthroplasty: a retrospective study. *Foot Ankle Orthop* 7(1).
<https://doi.org/10.1177/2473011421S0027>