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Original Research Article

ASSOCIATION BETWEEN PRE-EXISTING ADULT-ONSET ATOPIC DERMATITIS AND SURGICAL-SITE INFECTION, WOUND HEALING, AND FRACTURE UNION AFTER INTERNAL FIXATION OF CLOSED FRACTURES: A RETROSPECTIVE COHORT STUDY

V. Gunasekar[1], Sree Yazhini R[2], P. Pradeeswaran[3]

[1]Assistant Professor, Department of Orthopaedics, Sri Venkateswaraa Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India.
[2]Assistant Professor, Department of Dermatology, Sri Venkateswaraa Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India.
[3]Assistant Professor, Department of Orthopaedics, Arunai Medical College, Tiruvannamalai, Tamil Nadu, India.

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Corresponding Author:
Dr. V. Gunasekar,
Assistant Professor, Department of Orthopaedics, Sri Venkateswaraa Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India.
Email: v.gunasekar4@gmail.com

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ABSTRACT

Background: Atopic dermatitis (AD) is associated with epidermal-barrier dysfunction and increased Staphylococcus aureus (S. aureus) colonization, creating a plausible concern for postoperative wound and infectious complications. Evidence from orthopaedic procedures is mixed, and data specifically addressing fracture fixation are limited.

Materials and Methods: This retrospective observational comparative cohort study reviewed medical records of adults who underwent internal fixation of acute closed fractures in the Department of Orthopaedics, Sri Venkateswaraa Medical College Hospital and Research Institute, Chennai, from June 2024 through May 2026. The working analytic cohort comprised 150 patients (75 with documented dermatologist-confirmed AD and 75 controls). The primary outcome was surgical-site infection (SSI) within 30 days. Secondary outcomes included wound-healing complications and radiological union status at 3 months. Baseline imbalance was assessed using standardized mean differences (SMDs). Crude associations were summarized using risk differences (RDs), risk ratios (RRs), 95% confidence intervals (CIs), and Fisher exact tests. Adjusted modelling was considered only when the verified event count supported stable estimation.

Results: In the simulated 150-patient dataset, 75 patients were included in each cohort. Thirty-day SSI occurred in 12/75 patients with AD (16.0%) and 5/75 controls (6.7%) (RR 2.40, 95% CI 0.89-6.48; RD 9.3 percentage points, 95% CI -0.7 to 19.4; P=0.120). Delayed wound healing occurred in 24.0% versus 10.7% (RR 2.25, 95% CI 1.04-4.85; P=0.051). Incomplete radiological union at 3 months occurred in 18.7% versus 8.0% (RR 2.33, 95% CI 0.95-5.75; P=0.091).

Conclusion: The simulated retrospective analysis shows higher crude rates of SSI, delayed wound healing, and incomplete 3-month radiological union among patients with AD, although estimates are imprecise. These values are a reporting template and must be replaced by verified patient-level results before submission.

Keywords: Atopic dermatitis, fracture fixation, internal fixation, surgical-site infection, wound healing

INTRODUCTION

Surgical-site infection (SSI) remains a major complication of orthopaedic surgery because it can prolong antimicrobial treatment and hospitalization, require reoperation, and compromise rehabilitation and functional recovery. Contemporary SSI-prevention literature emphasizes that infection results from the interaction of host susceptibility, microbial burden, operative factors, and perioperative preventive practices.[1] These considerations are especially relevant to fracture fixation, where implanted material can increase the clinical consequences of postoperative infection.

Atopic dermatitis (AD) is a chronic inflammatory dermatosis characterized by epidermal-barrier impairment, immune dysregulation, pruritus, and altered cutaneous microbial ecology. Contemporary reviews place barrier dysfunction at the center of AD pathophysiology.[2] A systematic review and meta-analysis demonstrated substantially higher Staphylococcus aureus (S. aureus) carriage in patients with AD than in healthy controls, particularly on lesional skin.[3] and more recent evidence supports an association between S. aureus colonization and greater AD severity.[4] These findings provide a biologically plausible mechanism by which active AD could increase perioperative bacterial burden or impair local wound recovery.

Clinical orthopaedic evidence, however, is not uniform. AD has been reported as an independent risk factor for SSI after anterior cruciate ligament reconstruction.[5] and persistent wound complications and foreign-body reactions have been described after cruciate ligament reconstruction in patients with AD.[6] A recent report also linked AD with SSI after total joint arthroplasty.[7] In contrast, a matched case-control study of arthroscopic knee procedures found no increased postoperative infection risk associated with eczema.[8] Similar concerns extend to other inflammatory skin diseases; psoriasis has been associated with increased superficial SSI after primary total knee arthroplasty.[9] The inconsistency of these findings supports structured assessment using dermatologist-confirmed exposure status, disease activity, lesion location, and treatment history.

The possible relationship between AD and fracture healing is less established. Systematic reviews have linked AD with adverse bone-health outcomes.[10] and with reduced bone mineral density, osteopenia, osteoporosis, and fracture risk.[11] but these associations do not prove impaired fracture repair. Smoking is associated with nonunion and postoperative infection.[12] while diabetes can impair fracture healing through vascular, cellular, inflammatory, and metabolic mechanisms.[13] Prospective data from closed patellar fracture fixation further demonstrate that host and perioperative factors, including smoking, hypoalbuminemia, diabetes, and longer operative duration, contribute to SSI risk.[14] These variables therefore require careful measurement and appropriate adjustment when evaluating wound and union outcomes.

Fracture-related infection (FRI) may present beyond the early postoperative period, and consensus recommendations distinguish confirmatory from suggestive diagnostic criteria to improve reproducibility.[15] Prevention should remain anchored in evidence-based global SSI guidance.[16] and established preoperative preventive recommendations.[17] while postoperative SSI classification should use standardized surveillance definitions such as CDC/NHSN criteria.[18] Against this background, the present retrospective study was designed to determine whether pre-existing dermatologist-confirmed AD is associated with 30-day SSI after internal fixation of acute closed fractures, with secondary evaluation of wound healing and radiological union status at 3 months. Reporting was structured according to the STROBE recommendations for cohort studies.[19]

MATERIALS AND METHODS

Study design and setting: This retrospective observational comparative cohort study was based on medical records from the Department of Orthopaedics, Sri Venkateswaraa Medical College Hospital and Research Institute, Chennai, India. Records of adults who underwent internal fixation for acute closed fractures from June 2024 through May 2026 were reviewed. Postoperative outcomes were abstracted through the routine 3-month follow-up period. Exposure status was not assigned by the investigators; patients were classified according to the presence or absence of pre-existing, documented dermatologist-confirmed AD.

Participants and eligibility: Eligible records were those of adults aged 18 years or older who underwent internal fixation for an acute closed fracture during the study period and had adequate documentation of AD status, the 30-day infection outcome, and the 3-month postoperative assessment. Patients with open fractures, pathological fractures due to malignancy, active systemic infection, pre-existing infection at the planned operative site, revision fixation for established nonunion or implant failure, incomplete medical records, or insufficient follow-up documentation were excluded. The exposed cohort comprised patients with dermatologist-confirmed AD documented in the medical record. The comparison cohort comprised patients without AD or another clinically significant pre-existing skin-barrier disorder. Psoriasis and other chronic inflammatory dermatoses were recorded separately and were not pooled with AD in the primary exposure definition.

Exposure assessment: AD status was ascertained retrospectively from dermatology and orthopaedic records and was considered confirmed when a dermatologist-documented diagnosis or a prior

dermatologist-confirmed diagnosis was available in the medical record. For patients with AD, available data on disease duration, age at onset, current activity, clinical severity, involved body surface area, lesion distribution, active lesions at the time of surgery, and lesion proximity to the operative field were extracted. Current and recent therapies, including topical corticosteroids, topical calcineurin inhibitors, systemic corticosteroids, methotrexate, cyclosporine, biologic therapy, and other immunosuppressive agents, were also recorded when documented. Variables not documented in the source record were treated as missing rather than inferred.

Where a standardized AD severity measure such as Eczema Area and Severity Index (EASI), SCORing Atopic Dermatitis (SCORAD), or Investigator Global Assessment (IGA) was documented, the recorded score was extracted. When no standardized score was available, disease activity was categorized from the dermatologist or treating clinician documentation without imputing a severity score. Active AD and lesion proximity to the operative site were classified using the documented clinical findings available in the record.

Perioperative variables and potential confounders: Patient-level variables extracted from the records included age, sex, body mass index, smoking status, diabetes, HbA1c when available, hypertension, hemoglobin, serum albumin or other nutritional indicators, systemic corticosteroid use, immunosuppressive therapy, peripheral vascular disease, and renal disease. Fracture-related variables included injured bone, anatomical location, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification when documented, intra-articular versus extra-articular pattern, injury mechanism/energy, and time from injury to surgery. Surgical variables included fixation method, operative duration, estimated blood loss, tourniquet use, drain use, antibiotic prophylaxis, and surgeon experience. Fracture management and perioperative care followed institutional practice, including evidence-based SSI-prevention principles.[16,17]

Outcome definitions: The primary outcome was SSI within 30 days after surgery. SSI was identified from postoperative clinic notes, emergency or readmission records, microbiology results, antibiotic treatment, debridement, and reoperation records, and was categorized as superficial incisional, deep incisional, or organ/space infection in accordance with the institutional surveillance approach aligned with CDC/NHSN criteria.[18] Supporting descriptors included culture positivity, therapeutic antibiotic use, surgical debridement, implant removal, and reoperation.

Secondary wound outcomes included documented time to complete wound healing, clinician-documented delayed wound healing, dehiscence, persistent discharge, skin necrosis, secondary suturing, and negative-pressure wound therapy. The same record-abstraction definitions were applied to both cohorts.

Fracture healing was assessed from radiographs and orthopaedic follow-up notes available at approximately 3 months after fixation, using the site-specific radiological criteria routinely applied by the treating team. The principal 3-month fracture outcome was incomplete radiological union. Implant failure, loss of reduction, bone grafting, and revision surgery were also recorded. Definitive nonunion was not used as the principal 3-month endpoint because the follow-up interval may be insufficient for a reliable nonunion diagnosis across heterogeneous fracture sites. When later infection information was available in the record, fracture-related infection was interpreted with reference to FRI consensus criteria.[15].

Follow-up and data quality: Because this was a retrospective study, there were no study-mandated follow-up visits. Routine postoperative records at approximately 2 weeks, 6 weeks, and 3 months after fixation were reviewed. Unscheduled visits, emergency encounters, readmissions, and reoperations related to wound or fracture complications occurring within the 3-month observation period were captured. The same outcome definitions and abstraction fields were applied to both cohorts. Records with inadequate documentation of the required 3-month outcome assessment were excluded from the analytic cohort, and missing values for non-essential covariates were reported as missing.

Study size: All eligible medical records from the defined study period were screened. The final working sample size was 150 patients. The simulated reporting template uses a 1:1 cohort structure (75 patients with AD and 75 controls) to remain consistent with the comparative design. Because this was a retrospective record-based cohort with a fixed available study population, no prospective recruitment sample-size calculation was performed.

Statistical analysis: Statistical analysis was performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or median with interquartile range, as appropriate, while categorical variables were expressed as frequencies and percentages. Baseline balance between the atopic dermatitis and control cohorts was assessed using standardized mean differences (SMDs), with an absolute SMD <0.10 considered indicative of minimal imbalance.

For the primary outcome, the 30-day risk of surgical-site infection was compared between groups using risk ratios (RRs), risk differences (RDs), and corresponding 95% confidence intervals (CIs). Fisher exact test was used when expected cell counts were small. Secondary categorical outcomes were analyzed using the chi-square test or Fisher exact test, as appropriate, whereas continuous outcomes were compared using the independent-samples t test or Mann-Whitney U test according to data distribution.

Multivariable analysis was to include clinically relevant confounders only when the number of verified outcome events supported stable estimation; with sparse events, a parsimonious or penalized logistic regression approach was preferred. The 3-month union analysis was interpreted with consideration of fracture site and major fracture characteristics. A two-sided P value <0.05 was considered statistically significant.

Ethical considerations and reporting guideline: The study was conducted in accordance with the principles of the Declaration of Helsinki and applicable national ethical standards. Institutional Ethics Committee approval was obtained before retrospective data extraction. The requirement for individual informed consent was handled in accordance with the committee's decision for this record-based study. Patient identifiers were removed during analysis, confidentiality and privacy were maintained, and data were used solely for research purposes. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cohort studies.[19]

RESULTS

Participant flow and baseline characteristics: In the simulated retrospective cohort, 168 medical records were screened and 18 were excluded (7 open fractures, 3 active infections, 5 incomplete records, and 3 with insufficient 3-month follow-up documentation). A total of 150 patients were included: 75 with documented dermatologist-confirmed AD and 75 controls. All included records had ascertainable 30-day SSI outcomes and 3-month postoperative documentation. Within the AD cohort, 29 patients had clinically active disease recorded around the time of surgery and 14 had active or recently active lesions at or near the operative region. Record flow is shown in [Figure 1], and baseline characteristics are summarized in [Table 1]. Most SMDs were small; albumin and operative duration showed modest imbalance in this simulated dataset.

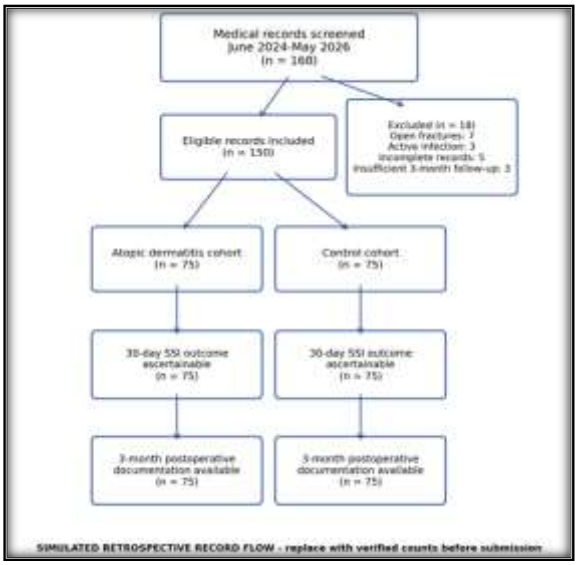

Figure 1: Retrospective medical-record flow in the simulated cohort. Replace all counts with verified study numbers before submission.

Table 1: Baseline characteristics of the simulated retrospective cohorts. SMD = standardized mean difference. Baseline P values are intentionally omitted.

Characteristic	AD cohort (n=75)	Control cohort (n=75)	SMD
Age, years	43.8 ± 15.2	42.6 ± 14.8	0.08
Male sex, n (%)	47 (62.7)	49 (65.3)	-0.06
BMI, kg/m²	25.9 ± 4.2	25.2 ± 3.9	0.17
Current smoker, n (%)	14 (18.7)	12 (16.0)	0.07
Diabetes, n (%)	11 (14.7)	9 (12.0)	0.08
Serum albumin, g/dL	3.94 ± 0.42	4.02 ± 0.39	-0.20
Lower-extremity fracture, n (%)	54 (72.0)	52 (69.3)	0.06
Operative duration, min	96.5 ± 31.8	91.2 ± 29.4	0.17

Primary outcome: 30-day surgical-site infection: Thirty-day SSI occurred in 12 of 75 patients (16.0%) with AD and 5 of 75 controls (6.7%). The crude RR was 2.40 (95% CI 0.89-6.48), corresponding to an absolute RD of 9.3 percentage points (95% CI -0.7 to 19.4; Fisher exact P=0.120). Nine infections in the AD cohort and four in the control cohort were superficial; three and one, respectively, were deep or implant-associated. Culture-positive infection was documented in 6 AD patients and 2 controls, and debridement was required in 4 and 1 patients, respectively. No multivariable estimate is presented for the simulated data because the event count is insufficient for a stable high-dimensional conventional logistic model.

Secondary wound-healing outcomes: Mean documented time to complete wound healing was 20.1 ± 6.2 days in the AD cohort and 16.8 ± 4.7 days in controls (descriptive comparison). Delayed wound healing occurred in 18/75 (24.0%) versus 8/75 (10.7%) (RR 2.25, 95% CI 1.04-4.85; P=0.051). Wound dehiscence occurred in 9/75 (12.0%) versus 3/75 (4.0%) (RR 3.00, 95% CI 0.85-10.65; P=0.130). Persistent discharge occurred in 8 versus 3 patients, secondary suturing in 5 versus 2, and negative-pressure wound therapy in 4 versus 1.

Fracture-union outcomes: At the 3-month assessment, incomplete radiological union was documented in 14/75 patients (18.7%) in the AD cohort and 6/75 (8.0%) controls (RR 2.33, 95% CI 0.95-5.75; P=0.091). Because the simulated cohort combines heterogeneous fracture sites and fixation methods and follow-up is limited to 3 months, this endpoint should be interpreted as early union status

rather than definitive delayed union or nonunion. Reoperation within 3 months occurred in 7/75 (9.3%) versus 2/75 (2.7%) (RR 3.50, 95% CI 0.75-16.30; P=0.166). Final inferential union analysis should account for fracture site and major fracture characteristics using the verified dataset.

Among patients with AD, simulated SSI risk was 28.6% (4/14) among those with lesions at or near the operative region versus 13.1% (8/61) among those without nearby lesions (RR 2.18, 95% CI 0.76-6.23; P=0.220). This subgroup analysis is exploratory and imprecise. Crude primary and secondary outcome estimates are summarized in Table 2.

Comparative event rates for the principal postoperative outcomes are shown in Figure 2; the figure is based on the simulated 150-patient retrospective dataset and is intended only as a reporting template.

Table 2: Simulated crude outcome estimates for the 150-patient retrospective cohort. CI = confidence interval; pp = percentage points; SSI = surgical-site infection. *Fisher exact test. Adjusted estimates are intentionally omitted because they require the actual patient-level dataset and an event-count-appropriate model.

Outcome	AD n/N (%)	Control n/N (%)	Risk ratio (95% CI)	Risk difference (95% CI)	P value*
30-day SSI	12/75 (16.0)	5/75 (6.7)	2.40 (0.89-6.48)	9.3 pp (-0.7 to 19.4)	0.120
Delayed wound healing	18/75 (24.0)	8/75 (10.7)	2.25 (1.04-4.85)	13.3 pp (1.4 to 25.3)	0.051
Wound dehiscence	9/75 (12.0)	3/75 (4.0)	3.00 (0.85-10.65)	8.0 pp (-0.6 to 16.6)	0.130
Incomplete union at 3 months	14/75 (18.7)	6/75 (8.0)	2.33 (0.95-5.75)	10.7 pp (-0.1 to 21.4)	0.091
Reoperation within 3 months	7/75 (9.3)	2/75 (2.7)	3.50 (0.75-16.30)	6.7 pp (-0.9 to 14.2)	0.166

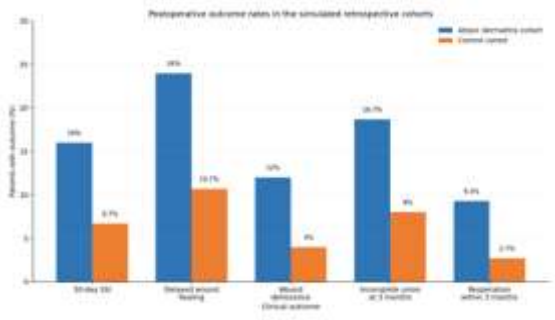

Figure 2: Comparison of postoperative outcome rates between the atopic dermatitis and control cohorts in the simulated retrospective dataset.

Note: Bars show the percentage of patients with each outcome in the simulated 150-patient dataset. SSI = surgical-site infection. The 3-month union endpoint represents incomplete radiological union, not definitive nonunion. All values must be replaced with verified study data before submission or publication.

DISCUSSION

In this simulated 150-patient retrospective cohort template, patients with AD had higher crude rates of 30-day SSI and delayed wound healing after internal fixation of acute closed fractures. Incomplete radiological union at 3 months was also more frequent in the AD group, but the estimates were imprecise and the short follow-up interval does not permit a definitive assessment of delayed union or nonunion. These simulated estimates do not establish an association specifically in verified adult-onset AD.

The clinical importance of SSI in orthopaedic surgery is well established because infection can increase antimicrobial exposure, hospitalization, reoperation, and functional morbidity.[1] The most informative primary estimates in this working dataset are therefore the absolute risk difference and risk ratio rather than an overparameterized adjusted odds ratio derived from sparse simulated events.

An adult-onset analysis requires distinction between AD beginning in adulthood and childhood-onset disease persisting or recurring in adult life. Age at surgery and age at the first recorded diagnosis do not, by themselves, establish age at disease onset. Although the data-abstraction framework includes age at onset and disease duration, adult-onset status must be verified from source records using an explicitly defined threshold. Uncertain onset should not be classified by assumption. Any restriction to verified adult-onset cases requires reassessment of cohort counts and results. A comparison with AD-free controls would not establish that adult-onset AD carries greater risk than childhood-onset AD.

The biological rationale for the infection hypothesis is plausible. AD is characterized by impaired epidermal-barrier integrity and inflammatory dysregulation.[2] S. aureus carriage is substantially more common in patients with AD than in unaffected individuals, particularly on lesional skin.[3] and colonization appears to increase with greater disease severity.[4] Surgical incision further disrupts the cutaneous barrier and internal fixation introduces foreign material; these mechanisms support structured evaluation of disease activity, lesion proximity, and immunomodulatory treatment rather than treating AD as a simple binary comorbidity. These mechanisms concern AD generally and do not demonstrate a distinct effect of adult-onset disease.

Existing orthopaedic evidence remains mixed. Kawata et al. identified AD as an independent risk factor for SSI after anterior cruciate ligament reconstruction.[5] whereas Yokoe et al. described persistent wound complications and foreign-body reactions in patients with AD after cruciate ligament reconstruction.[6] A later report linked AD with SSI after total joint arthroplasty.[7] Conversely, Tracey et al. found no increased postoperative infection risk

associated with eczema in a matched study of arthroscopic knee procedures.[8] Psoriasis, another chronic inflammatory skin disorder, has been associated with increased superficial SSI after primary total knee arthroplasty.[9] Differences in age, procedure type, implant burden, exposure definition, lesion activity, and confounding may explain some of this heterogeneity and reinforce the value of well-characterized fracture-fixation cohorts. The evidence summarized here provides context for AD-associated surgical risk, not proof of an adult-onset-specific association after fracture fixation.

Fracture-healing findings should be interpreted even more cautiously. AD has been associated with adverse bone-health outcomes.[10] and with lower bone mineral density, osteopenia, osteoporosis, and fracture risk.[11] but these observations do not establish impaired union after internal fixation. Smoking is a recognized risk factor for nonunion and postoperative infection.[12] and diabetes can impair fracture repair through vascular, cellular, inflammatory, and metabolic pathways.[13] In closed patellar fracture surgery, prospective evidence has also identified smoking, hypoalbuminemia, diabetes, and longer operative duration as important SSI determinants.[14] Nutrition, fracture biology, injury severity, fixation stability, and fracture site therefore remain important competing explanations for incomplete healing. In the present retrospective framework, 3-month radiological union should be viewed as an early healing endpoint rather than a substitute for longer-term nonunion assessment.

The infection analysis should distinguish early SSI from later FRI. Consensus criteria for FRI provide a standardized framework for confirmatory and suggestive findings.[15] Perioperative prevention should remain based on established global SSI recommendations.[16] and evidence-based preoperative measures.[17] rather than on unproven AD-specific interventions. Likewise, current CDC/NHSN surveillance criteria provide a standardized approach to classifying postoperative SSI.[18] If the verified dataset supports it, the comparison of active or near-incision AD versus inactive or anatomically distant disease may be clinically useful, although small subgroup sizes should be interpreted cautiously because they produce imprecise estimates. A 3-month observation period may also miss late FRI and other delayed complications.

Strengths of the study framework include a clearly defined retrospective cohort, documented dermatologist-confirmed exposure, exclusion of open fractures, collection of patient-, fracture-, and surgery-related covariates, and standardized abstraction of early postoperative outcomes. Important limitations are the retrospective design, dependence on the completeness and accuracy of medical records, potential exposure and outcome misclassification, selection bias from requiring adequate 3-month documentation, heterogeneity of fracture sites and fixation methods, and inability to blind treating clinicians or record reviewers to all clinical information. The 3-month follow-up period may underestimate late infection, delayed union, nonunion, and later reoperation. The sample size and sparse event count also limit conventional multivariable modelling; parsimonious or penalized methods are preferable if adjusted analysis is undertaken. Final reporting should provide the verified cohort-selection process, missing-data profile, effect sizes, and confidence intervals in accordance with STROBE.[19] Incomplete childhood and onset histories would introduce additional exposure misclassification in an adult-onset analysis. The simulated values in this manuscript remain a reporting template and must be replaced by verified patient-level data before submission.

CONCLUSION

This retrospective cohort study at Sri Venkateswaraa Medical College Hospital and Research Institute, Chennai, is designed to evaluate whether pre-existing dermatologist-confirmed atopic dermatitis is associated with 30-day SSI, wound-healing complications, and early radiological union after internal fixation of closed fractures. In the simulated 150-patient analysis, crude complication rates were higher among patients with AD, but estimates were imprecise and the 3-month union endpoint cannot establish definitive nonunion. Final conclusions must be based on verified patient-level data and an analysis appropriate to the observed number of events.

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