

Risk Factors for Failure of Conservative Treatment Requiring Surgical Intervention in Male Patients with First-Time Acute Lateral Ankle Sprains

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Research Article

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Abstract

Background

Acute lateral ankle sprain (ALAS) is a common sports-related injury. Although most patients achieve satisfactory recovery following conservative treatment, a subset ultimately requires surgical intervention. Early identification of individuals at high risk of conservative treatment failure is therefore of substantial clinical importance.

Purpose

To identify independent predictors of conservative treatment failure requiring subsequent surgical intervention in young and middle-aged male patients with a first-time ALAS after 6 months of standardized nonoperative management.

Study Design:

Cohort study; Level of evidence, 2.

Methods

This retrospective cohort study included young and middle-aged male patients presenting with a first-time ALAS at our institution between January 2023 and December 2025. All patients underwent standardized conservative treatment based on the PEACE & LOVE principles for at least 12 weeks and completed a minimum follow-up of 12 months. Baseline demographic characteristics, clinical assessment parameters (including the 10-Meter Walk Test[10MWT], Visual Analog Scale [VAS], Pain Catastrophizing Scale [PCS], Hospital Anxiety and Depression Scale [HADS], and Foot and Ankle Ability Measure–Sports Subscale [FAAM-Sport]), as well as ankle magnetic resonance imaging (MRI) findings obtained within 2 weeks of injury (including talus bone marrow lesions [BMLs] and tibiotalar joint effusion), were collected. The primary outcome was conversion to surgical treatment due to failure of conservative management at 6 months after injury. Multivariable logistic regression analysis was performed to identify independent predictors, and receiver operating characteristic (ROC) curve analysis was used to evaluate the predictive performance of the model.

Results

A total of 266 patients were included in the final analysis, with a mean age of 29.9 ± 6.7 years (range, 18–45 years). Among them, 90 (33.8%) underwent surgical intervention at 6 months due to failure of conservative treatment. Multivariate logistic regression analysis demonstrated that moderate tibiotalar

joint effusion (OR = 4.14, 95% CI: 1.48–11.54, $P = 0.007$), severe tibiotalar joint effusion (OR = 5.90, 95% CI: 1.65–21.04, $P = 0.006$), extensive talar BMLs (OR = 5.11, 95% CI: 1.37–19.11, $P = 0.015$), a HADS score ≥ 8 (OR = 1.98, 95% CI: 1.61–2.43, $P < 0.001$), and a 10MWT time ≥ 10 seconds (OR = 2.09, 95% CI: 1.56–2.80, $P < 0.001$) were independent risk factors for conservative treatment failure requiring surgery. The predictive model demonstrated good discriminative ability, with an area under the ROC curve (AUC) of 0.840, a sensitivity of 0.733, and a specificity of 0.846, and showed satisfactory calibration.

Conclusion

Extensive talar BMLs, tibiotalar joint effusion, elevated anxiety and depression levels, and impaired walking function are independent predictors of conservative treatment failure in young and middle-aged male patients with a first-time ALAS. Early identification of these risk factors may facilitate risk stratification and optimize clinical decision-making regarding treatment strategies.

1 Introduction

Acute lateral ankle sprain (ALAS) is a common sports injury in foot and ankle surgery. Clinically, patients may present with pain, swelling, weight-bearing limitation, and gait abnormalities[1]. Although current clinical guidelines generally recommend early functional conservative treatment as the first-line treatment strategy[2–4], approximately 20%–40% continue to experience persistent symptoms[5]. And eventually require surgical intervention due to the failure of conservative treatment[4]. Early identification of individuals at high risk of conservative treatment failure is therefore of considerable clinical importance, as it may facilitate timely treatment optimization and prevent prolonged ineffective rehabilitation.

In recent years, increasing attention has been directed toward the development of multidimensional predictive models incorporating post-injury clinical manifestations, imaging findings, and even psychological factors. However, most existing studies have been conducted in mixed-sex populations[6, 7]. Previous research has demonstrated substantial sex-related differences in musculoskeletal disorders with respect to biomechanics, neuromuscular control, hormonal regulation, and recovery patterns following injury[8, 9]. Such differences may introduce considerable heterogeneity and confounding effects when evaluating prognostic factors. To minimize these potential sources of bias, the present study specifically focused on male patients experiencing a first-time ALAS.

Accordingly, we conducted a retrospective cohort study involving a relatively homogeneous population of young and middle-aged men with a first-time ALAS. We hypothesized that, after controlling for the potentially confounding effect of sex, demographic characteristics, functional performance, psychological status, and magnetic resonance imaging (MRI) findings obtained during the acute phase of injury would be associated with subsequent failure of conservative treatment requiring surgical intervention. Therefore, the aims of this study were to identify independent predictors of conservative treatment failure in male patients undergoing standardized nonoperative management and to develop a

dedicated early risk prediction model. The findings may contribute to more accurate risk stratification and facilitate individualized, stepwise rehabilitation management for physically active male patients with ALAS.

2 Methods

2.1 Study Design and Participants

This retrospective cohort study reviewed the medical records of male patients with first-time ALAS who presented to the Department of Sports Medicine or Emergency Department of our institution between January 2023 and December 2025. Patients meeting the following inclusion criteria were enrolled based on medical record information: (1) first-time acute lateral ankle sprain; (2) age between 18 and 45 years; (3) completion of clinical assessment within 2 weeks after injury; (4) initial treatment with standardized conservative management; and (5) completion of at least 12 months of follow-up. The exclusion criteria were as follows: (1) previous history of ankle sprain or ankle surgery; (2) concomitant ankle fracture, dislocation, or intra-articular loose body; (3) other severe lower-extremity injuries; (4) neurological disorders or other diseases affecting motor function; (5) incomplete imaging data; and (6) inability to complete all follow-up assessments and tests or loss to follow-up. All participants provided written informed consent prior to testing. The study protocol was approved by the institutional ethics committee (Approval No. XXXXXXXX).

2.2 Study Procedures

2.2.1 Baseline Assessment

At enrollment, demographic and clinical data including age, sex, body mass index (BMI), injured side, and activity level assessed using the Tegner Activity Scale were recorded for all participants (Fig. 1). Pain severity was evaluated using the Visual Analog Scale (VAS) and the Pain Catastrophizing Scale (PCS), while psychological status was assessed using the Hospital Anxiety and Depression Scale (HADS). Objective clinical examination (including the anterior drawer test, inversion tilt test, and 10-meter walk test [10MWT][10]) findings at the initial presentation following the ankle sprain, together with magnetic resonance imaging (MRI) data, were retrospectively collected through a review of electronic medical records. For descriptive analyses, results of the 10MWT were presented as continuous variables (mean $\pm$ SD). For multivariable logistic regression, 10 seconds was selected as the cutoff value for the 10MWT based on previous studies[11].

2.2.2 Interventions

All patients received standardized conservative treatment immediately after their initial visit. Management was performed according to the internationally recommended PEACE & LOVE principles [12], including protection, elevation, avoidance of anti-inflammatory medications, compression, and appropriate loading to reduce pain and swelling, while simultaneously emphasizing optimism, patient

education, and maintenance of vascularization. As symptoms gradually improved, patients progressed to the functional rehabilitation phase. The rehabilitation program primarily consisted of early ankle range-of-motion exercises, proprioceptive training, neuromuscular control training, balance training, muscle strengthening exercises, and progressive return-to-sport training. All rehabilitation protocols were supervised by professional rehabilitation therapists, with treatment sessions conducted 2–3 times per week for 30 minutes per session during the initial 12-week intervention period. Subsequent rehabilitation frequency could be reduced to 1–2 sessions per week for 30 minutes per session, with a minimum intervention duration of 12 additional weeks. The detailed rehabilitation protocol is provided in **Supplementary Appendix 1**.

2.2.3 Follow-up and Outcome Measures

The primary endpoint of this study was whether patients underwent surgical intervention at 6 months after injury due to failure of conservative treatment. To minimize the influence of short-term symptom fluctuations and delayed surgical decision-making on outcome assessment, follow-up was further extended to 12 months to describe the final clinical outcomes of patients; however, 12-month outcomes were not included in the primary predictive model analysis. In the present study, the indications for defining conservative treatment failure requiring surgical intervention were as follows [13]: (1) unsatisfactory outcomes after 6 months of standardized conservative treatment, including brace protection, proprioceptive training, peroneal muscle strengthening, and physical therapy; (2) persistent pain along the lateral collateral ligament complex or other regions of the ankle, and/or decreased ankle stability resulting in recurrent sprains or difficulty walking on uneven surfaces, thereby significantly affecting daily life and sports participation; and (3) imaging confirmation of lateral ankle ligament injury and ankle instability using stress radiography, magnetic resonance imaging (MRI), or musculoskeletal ultrasonography. Patients meeting all of the above criteria were assigned to the surgical group, whereas the remaining patients were classified into the non-surgical group. In addition, pain severity was assessed using the Visual Analog Scale (VAS), functional outcomes were evaluated using the Foot and Ankle Ability Measure–Sport subscale (FAAM-Sport), and psychological status was assessed using the Hospital Anxiety and Depression Scale (HADS) and the Pain Catastrophizing Scale (PCS). For descriptive analyses, HADS scores were presented as continuous variables (mean $\pm$ SD). For multivariable logistic regression, HADS was dichotomized using the established clinical cutoff value of 8 points [14, 15] to identify clinically relevant symptoms of anxiety and depression.

2.2.4 Imaging Analysis

All patients underwent ankle magnetic resonance imaging (MRI) within 2 weeks after injury. MRI evaluation primarily focused on ligament injuries, bone marrow lesions (BMLs), and joint effusion. The presence of talur BMLs was primarily assessed and graded according to standard criteria [16]. In addition, effusion of the tibiotalar and subtalar joints was assessed and graded according to the degree of joint capsule distension [17]. All MRI images were independently reviewed by two experienced musculoskeletal radiologists. In cases of disagreement, a consensus was reached through discussion.

2.3 Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 27.0. Continuous variables with normal distribution were expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$), and comparisons between groups were conducted using the independent-samples t-test. Non-normally distributed data were presented as median (interquartile range) and compared using the Mann–Whitney U test. Categorical variables were expressed as frequencies (percentages) and analyzed using the chi-square test or Fisher’s exact test, as appropriate. Surgical intervention status was defined as the dependent variable. Variables with $P < 0.10$ in univariate analyses were entered into a multivariate logistic regression model to identify independent predictors of failure of conservative treatment requiring subsequent surgical intervention in patients with ALAS. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the predictive performance of the model, and the area under the curve (AUC) was calculated. Model goodness-of-fit was assessed using the Hosmer–Lemeshow test. A two-sided P value < 0.05 was considered statistically significant.

3 Results

3.1 Overall Trajectories and Demographics

A total of 266 male patients with first-time ALAS were included in this study. Baseline demographic characteristics and clinical assessment results (Table 1) showed that the mean age of the entire cohort was 29.9 ± 6.7 years. The mean interval from injury to clinical presentation was 2.8 ± 2.0 days. After 6 months of standardized conservative treatment initiated at the first visit, 176 patients (66.2%) achieved satisfactory clinical recovery and were classified into the non-surgical group, whereas 90 patients (33.8%) were considered to have failed conservative treatment and subsequently underwent surgical intervention (surgical group). At the final 12-month follow-up, among the 176 patients in the non-surgical group, 102 patients had achieved complete recovery, 37 continued to experience mild residual symptoms and remained under conservative management, 17 experienced occasional recurrence after conservative treatment but did not meet the indications for surgery, and 20 patients ultimately underwent surgical intervention.

Table 1

Baseline demographics, clinical assessments, and imaging features of the total cohort and univariate analysis based on 6-month final outcomes.

Variables	Total Cohort (n = 266)	Non-surgical group (n = 176)	Surgical Group (n = 90)	P value
Demographics				
Age (years)	29.9 ± 6.7	30.0 ± 6.6	29.5 ± 7.0	0.580
BMI (kg/m ²)	24.1 ± 4.2	23.5 ± 4.1	25.2 ± 4.3	0.002
Tegner score	5.2 ± 1.4	5.4 ± 1.3	4.9 ± 1.4	0.009
Visit days(day)	2.8 ± 2.0	2.6 ± 1.8	3.2 ± 2.4	0.018
Clinical Assessments (Baseline)				
10m walk test (sec)	10.4 ± 1.7	9.3 ± 0.7	12.6 ± 0.9	<0.001
Ant. Drawer Test				0.380
Grade 0	170(63.9)	117(66.5)	53(58.9)	
Grade 1	71(26.7)	45(25.6)	26(28.9)	
Grade 2	25(9.4)	14(8.0)	11(12.2)	
VAS	5.3 ± 1.8	5.4 ± 1.8	5.1 ± 1.9	0.288
PCS	25.1 ± 6.9	24.9 ± 7.0	25.3 ± 6.8	0.652
HADS	8.1 ± 3.8	6.2 ± 2.7	11.6 ± 3.1	<0.001
FAAM-Sport	32.1 ± 4.5	32.2 ± 4.8	31.8 ± 3.9	0.473
Imaging Features (Baseline)				
PTFL Injury (Yes)	61(22.9)	39(22.2)	22(24.4)	0.675
Talus BML				<0.001
Grade 0	70(26.3)	59(33.5)	11(28.2)	
Grade 1	136(51.1)	87(49.4)	49(57.1)	
Grade 2	60(22.6)	30(17.0)	30(33.3)	
Effusion of tibiotalar joint				<0.001
0 (normal)	100(37.6)	86(48.9)	14(15.6)	

Variables	Total Cohort (n = 266)	Non-surgical group (n = 176)	Surgical Group (n = 90)	P value
Demographics				
1 (< 50% of maximum capsular distension)	110(41.4)	69(39.2)	41(45.6)	
2 (≥ 50% of maximum capsular distension)	56(21.1)	21(11.9)	35(38.9)	

3.2 Independent Risk Factors for Conservative Failure

Based on the baseline comparisons between groups, variables with potential clinical relevance or a P value < 0.10 in the univariate analyses were entered into the multivariable logistic regression model (Table 2). Following stepwise variable selection, four variables were retained in the final model: talus BMLs, tibiotalar joint effusion, 10MWT, and Hospital Anxiety and Depression Scale (HADS) score (Table 2).

Compared with patients without significant tibiotalar joint effusion, those with moderate effusion had approximately a fourfold increased risk of conservative treatment failure (OR = 4.14, 95% CI: 1.48–11.54, $P = 0.007$), whereas patients with severe effusion had an approximately 5.9-fold increased risk (OR = 5.90, 95% CI: 1.65–21.04, $P = 0.006$).

Talus BMLs was also identified as an independent risk factor. Compared with patients without evident talus BMLs, those with extensive talar BMLs exhibited an approximately fivefold higher risk of conservative treatment failure (OR = 5.11, 95% CI: 1.37–19.11, $P = 0.015$). Although patients with moderate talar BMLs demonstrated a trend toward an increased risk (OR = 3.57, 95% CI: 0.90–14.15), the association did not reach statistical significance ($P = 0.071$).

In addition, patients requiring ≥ 10 seconds to complete the 10MWT at the initial assessment were at a significantly greater risk of subsequently undergoing surgical intervention (OR = 2.09, 95% CI: 1.56–2.80, $P < 0.001$). Likewise, patients with a HADS score ≥ 8 had a 1.98-fold higher risk of conservative treatment failure than those with a HADS score < 8 (OR = 1.98, 95% CI: 1.61–2.43, $P < 0.001$).

After adjustment for potential confounders, age, body mass index (BMI), activity level, and time from injury to initial presentation were not independently associated with treatment failure and were therefore excluded from the final model.

Table 2
Multivariate logistic regression analysis of independent risk factors predicting final conservative treatment failure leading to surgical intervention.

Variables	OR	95% CI	P value
Effusion of tibiotalar joint			
0 (normal)	reference	-	-
1 (< 50% of maximum capsular distension)	4.13	1.48–11.54	0.007
2 (50% of maximum capsular distension)	5.90	1.65–21.04	0.006
Talus BML			
Grade 0	reference	-	-
Grade 1	5.11	1.37–19.11	0.015
Grade 2	3.57	0.90-14.15	0.071
HADS	1.98	1.61–2.43	<0.001
10m walk test	2.09	1.56–2.80	<0.001

3.3 Model Predictive Performance and Calibration

A clinical prognostic prediction model was subsequently established based on the independent risk factors identified above, followed by receiver operating characteristic (ROC) curve analysis. The results demonstrated that the model achieved an area under the curve (AUC) of 0.840, indicating good predictive performance. At the optimal cutoff value, the model showed a sensitivity of 0.733, specificity of 0.846, and a Youden index of 0.579. Furthermore, the Hosmer–Lemeshow goodness-of-fit test indicated satisfactory calibration and overall model fit. (Fig. 2)

4 Discussion

In this retrospective study of patients with a first-time ALAS, we found that despite receiving standardized conservative treatment, 33.8% of patients ultimately underwent surgical intervention within 6 months because of persistent symptoms or unsatisfactory functional recovery. Multivariable logistic regression analysis further demonstrated that talus BMLs, tibiotalar joint effusion, elevated Hospital Anxiety and Depression Scale (HADS) scores, and prolonged 10MWT time were independent predictors of conservative treatment failure requiring surgery.

Compared with previous studies, most prognostic investigations in ALAS have primarily focused on the development of chronic ankle instability (CAI) or persistent symptoms[12, 13, 18]. However, CAI itself represents a highly heterogeneous condition and does not necessarily imply that all affected patients will ultimately require surgical intervention. Some individuals continue to achieve satisfactory functional outcomes through prolonged rehabilitation despite recurrent sprains or subjective instability[19]. In

contrast, patients who eventually undergo surgery following unsuccessful conservative treatment typically face a substantially longer recovery period, increased treatment costs, and greater healthcare resource utilization[20]. Therefore, we selected conversion to surgical treatment as the primary outcome because it directly reflects the failure of standardized conservative management. Nevertheless, surgical decision-making may also be influenced by patient expectations, occupational demands, sports participation levels, and surgeon preference. Accordingly, this endpoint should be interpreted as a pragmatic clinical outcome rather than a purely biological outcome.

Regarding imaging findings, this study identified baseline MRI-detected talus BMLs as an important imaging-related risk factor, particularly grade I BMLs, which were associated with a significantly increased risk of conservative treatment failure. This finding is broadly consistent with previous studies suggesting that bone contusions and other intra-articular abnormalities may be associated with persistent symptoms and delayed functional recovery following ankle sprain[11, 21]. Earlier investigations have primarily focused on the severity of lateral ligament injuries themselves[22, 23]. However, in the present study, posterior talofibular ligament (PTFL) injury did not remain significant in the final multivariable model, whereas talar BMLs retained independent prognostic value. One possible explanation is that talar BMLs may be associated with concomitant intra-articular abnormalities that are not fully reflected by ligament injury grading alone[23]. In addition, talus BMLs have been reported to correlate with the overall severity of ankle trauma and may therefore represent a surrogate imaging marker of injury burden[22]. Further studies are needed to clarify the mechanisms underlying this association and to determine the relative prognostic significance of different structural abnormalities following ALAS.

One of the most important findings of the present study was that tibiotalar joint effusion was an independent predictor of conservative treatment failure. Moreover, the risk of subsequent surgical intervention increased progressively with increasing severity of joint effusion. Joint effusion is generally considered an important indicator of intra-articular injury severity and inflammatory response[17, 22]. Previous studies have shown that substantial ankle joint effusion following acute sprain is frequently associated with more severe ligamentous injury and osteochondral involvement and may reflect a greater intra-articular inflammatory response. [17, 24]. Excessive intra-articular fluid may not only reflect greater structural damage but may also contribute with proprioceptive input and restoration of normal joint kinematics, thereby compromising rehabilitation outcomes[25]. Our findings further suggest that reactive intra-articular changes observed on early MRI may provide important prognostic information in addition to the assessment of ligament integrity.

Besides tibiotalar joint effusion, extensive talus BMLs emerged as another important imaging predictor. Interestingly, grade 1 talar BML remained significantly associated with conservative treatment failure, whereas grade 2 lesions did not reach statistical significance after multivariable adjustment. This finding may appear counterintuitive. Although grade 2 talus BMLs did not reach statistical significance after multivariable adjustment, the effect estimate remained elevated and in the same direction as that of grade 1 lesions. Given the relatively small sample size of the grade 2 subgroup and the wide confidence

intervals, the absence of statistical significance should be interpreted with caution. Furthermore, the decision to proceed with surgery is influenced by persistent symptoms and functional instability rather than MRI findings alone. Severe talus BMLs often indicates greater impact loading at the time of injury[26, 27]. Such patients may not only experience localized pain and inflammatory responses, but may also develop subchondral bone stress alterations[18] and impaired proprioceptive function[28], thereby negatively affecting subsequent neuromuscular recovery. Consequently, deficits in dynamic stability, motor control, and performance during complex movement tasks may persist, ultimately manifesting as recurrent “giving way” episodes or increased instability during sports activities, thereby necessitating further surgical intervention[19]. The lack of statistical significance for grade 2 lesions may be attributable to the relatively small sample size within this subgroup, resulting in wider confidence intervals and reduced statistical power. Therefore, the relationship between lesion severity and treatment outcomes warrants further investigation in larger prospective cohort studies.

In addition to structural injury, another important finding of this study was the association between psychological factors and prognosis. Patients with higher HADS scores were more likely to experience failure of conservative treatment. This finding is consistent with the growing emphasis on the “biopsychosocial model” in sports injury research in recent years[29–31]. Previous studies have shown that Compared with patients with chronic pain or long-term functional impairment, individuals in the acute injury stage may be more likely to experience uncertainty and anxiety regarding the recovery process[32]. And anxiety, fear of reinjury, and negative emotional states may not only influence patients’ subjective perception of injury, but also affect their participation in rehabilitation and the recovery process[33]. Some patients with relatively mild objective injuries may nevertheless develop activity avoidance, excessive protection, or reluctance to bear weight because of fear of recurrent injury, which may subsequently impair neuromuscular recovery and functional reconstruction over time[34]. Some patients, despite having no severe structural damage, may avoid weight-bearing, reduce physical activity, or even withdraw from rehabilitation exercises because of concerns about recurrent ankle sprain or pain during movement[30]. Although such protective behaviors may temporarily alleviate discomfort in the early stage, prolonged avoidance and excessive protection may adversely affect the restoration of normal ankle movement patterns and neuromuscular control, thereby further impairing functional recovery.

In addition, We also found that prolonged 10MWT performance was independently associated with an increased risk of subsequent surgery. The 10MWT is a simple and clinically feasible functional assessment tool[10]. Its results not only reflect pain and weight-bearing capacity, but also partially represent dynamic stability and gait control ability[35]. Compared with isolated static ligament laxity examinations, walking performance may better reflect patients’ integrated functional status during actual sports participation and daily activities[36]. Therefore, combining simple functional testing during the early acute phase may help identify patients at high risk of poor recovery.

The prediction model established based on the above risk factors demonstrated satisfactory discrimination and calibration performance, suggesting that comprehensive early risk assessment

integrating demographic, functional, psychological, and MRI-related factors may have meaningful clinical value. For patients presenting with high-risk characteristics, more aggressive interventions and closer follow-up surveillance may be warranted in clinical practice, enabling more timely surgical decision-making, shortening the overall treatment duration, and preventing patients from entering a prolonged vicious cycle of “persistent symptoms–severe functional limitation–ongoing anxiety,” rather than relying solely on traditional conservative immobilization strategies.

Several limitations of this study should be acknowledged. First, this was a single-center retrospective study and therefore remains susceptible to selection bias and information bias. Second, after MRI variable stratification, several subgroups contained relatively small sample sizes, resulting in wide confidence intervals for certain odds ratio estimates and introducing uncertainty regarding the magnitude of observed associations. Although the direction and statistical significance of these effects remained generally consistent, confirmation in larger prospective cohorts is necessary. Third, psychological status was assessed only at baseline, and dynamic changes in psychological factors throughout the rehabilitation process were not evaluated. Furthermore, although all patients received standardized conservative treatment, completion of home-based exercises could not be fully quantified or controlled, which may have influenced the results. Finally, this study used “conversion to surgery at 6 months” as the primary outcome measure. Although this endpoint may better reflect clinically meaningful “conservative treatment failure” compared with CAI alone, surgical decision-making itself is still influenced by multiple factors, including patients’ athletic demands, occupational characteristics, pain tolerance, and physician judgment. Therefore, despite the use of relatively clear surgical indications, some degree of individualized variation between patients likely remained unavoidable.

5 Conclusion

Approximately one-third of patients with a first-time ALAS required surgical intervention after unsuccessful standardized conservative treatment. Extensive talus BMLs, tibiotalar joint effusion, higher HADS scores, and prolonged 10MWT performance were independent predictors of treatment failure. Early multidimensional assessment incorporating MRI findings, psychological status, and functional performance may facilitate risk stratification and optimize treatment decision-making.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of **The 923 Hospital of Joint Logistic Support Force of PLA of China** (No. 923LL-KY-2026LW-036-01). Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy and ethical restrictions but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Zou, K. wrote the main manuscript, Chen, G. and Shi, D. were responsible for data collection, Jiang, Y. prepared figures, and Xu, G. designed the entire study.

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Figures

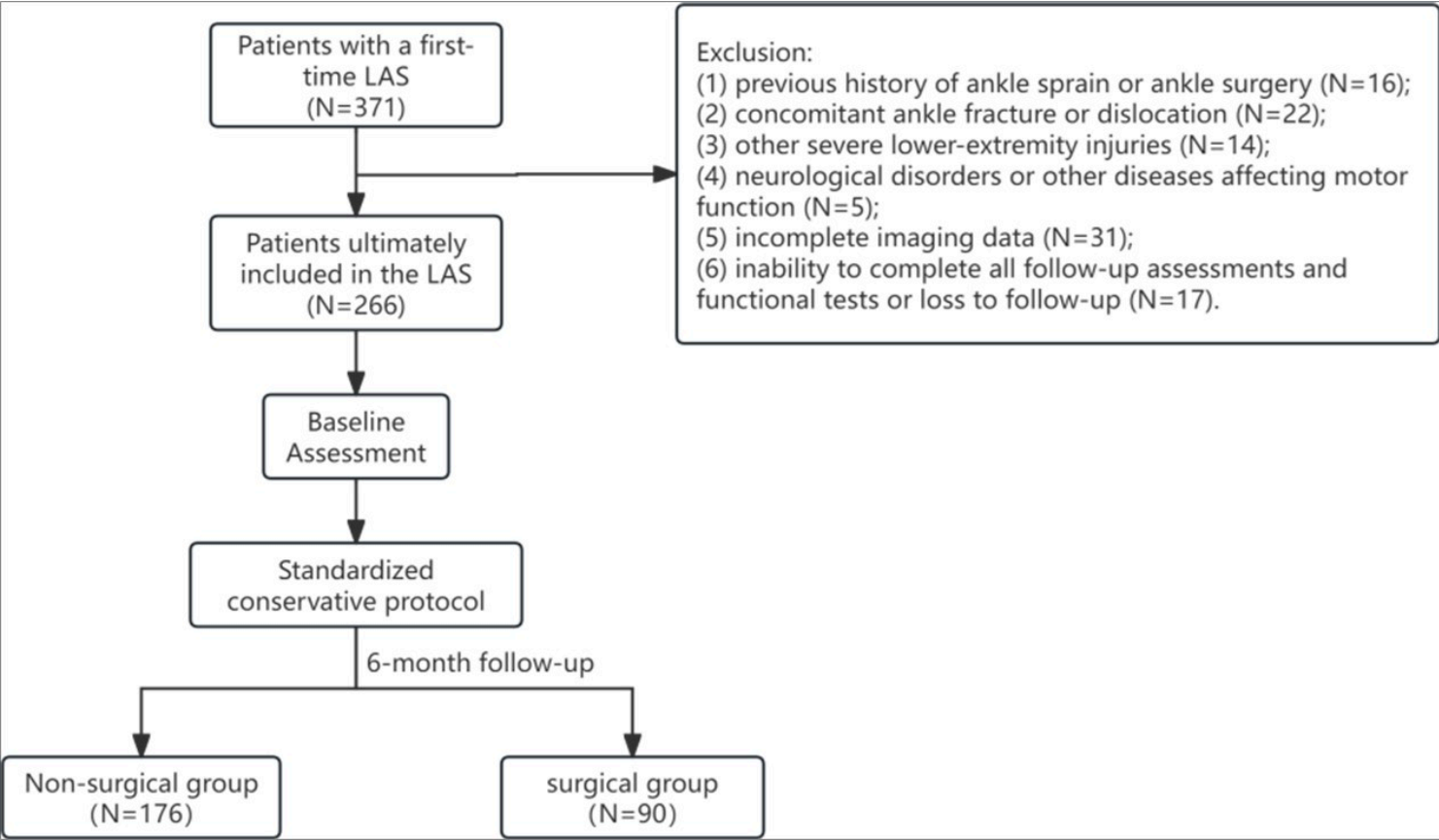


Figure 1

Flowchart

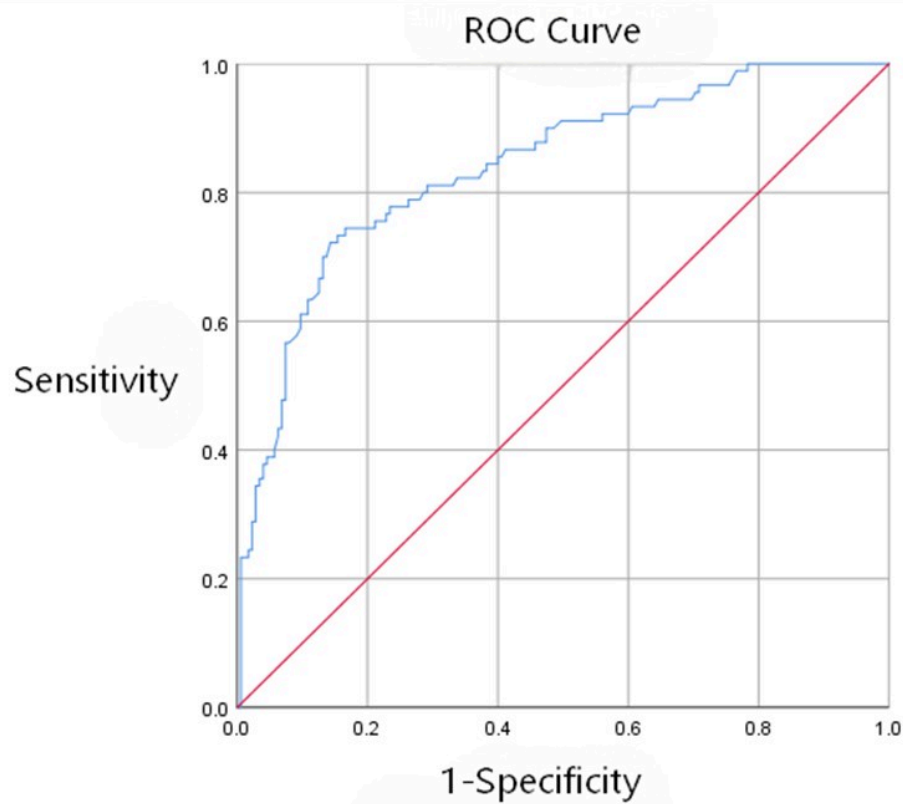


Figure 2

Receiver operating characteristic (ROC) curve of the predictive model for estimating surgical risk after conservative treatment failure.

Supplementary Files

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- [SupplementaryAppendix1.docx](#)