Am J Transl Res 2025;17(6):4288-4296
www.ajtr.org /ISSN:1943-8141/AJTR0163287

Original Article

Body mass index correlates with pain, functional recovery and complications in anterior talofibular ligament arthroscopic surgery

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Received January 13, 2025; Accepted May 11, 2025; Epub June 15, 2025; Published June 30, 2025

Abstract: Objective: To explore the correlation between body mass index (BMI) and ankle joint function recovery and rehabilitation outcomes in patients with anterior talofibular ligament (ATFL) injury after arthroscopic surgery. Methods: A retrospective study was conducted on 106 ATFL injury patients who underwent arthroscopic ATFL reconstruction in The First People's Hospital of Jiashan from January 2021 to December 2023. Based on BMI, the patients were divided into non-overweight (BMI 18.5-23.9 kg/m^2), overweight (BMI 24.0-27.9 kg/m^2), and obesity (BMI > 28.0 kg/m^2) groups. Intraoperative parameters, preoperative and postoperative pain were measured by visual analogue scale (VAS), ankle function was evaluated by American Orthopedic Foot and Ankle Society (AOFAS) and Carlson Ankle Function Score (KAFS), and postoperative complications were compared among the three groups. The relationship between BMI and postoperative ankle function recovery was analyzed. Results: Postoperative VAS scores decreased remarkably across all three groups, with non-overweight group exhibiting the lowest VAS score, followed by overweight and obesity groups ($P < 0.05$). AOFAS and KAFS scores notably increased after surgery in all three groups, with non-overweight group demonstrating the most obvious improvement, followed by overweight and obesity groups ($P < 0.05$). Complications incidence was 4.35%, 17.95%, and 58.62% in non-overweight, overweight, and obesity groups, respectively ($P < 0.05$). BMI correlated positively with VAS and negatively with AOFAS and KAFS. Conclusion: Higher BMI is associated with more server post-surgical pain, worse ankle function recovery, and poorer rehabilitation outcomes.

Keywords: Body mass index, anterior talofibular ligament, arthroscopy, ankle function, correlation

Introduction

Anterior talofibular ligament (ATFL) injury is one of the most common ankle sprains, particularly prevalent among athletes and individuals engaged in activities that place frequent stress on ankle joint due to high-intensity torsional and tensile forces [1]. Ankle sprains account for 15-30% of all sports-related injuries, with lateral collateral ligament injury representing approximately 90% of these sprains. Of those affected, nearly 40% develop chronic lateral ankle instability (CLAI), which manifests as symptoms such as fear of walking at night, persistent ankle swelling, pain, and functional decline [2-4]. If left untreated or improperly managed, CLAI can significantly impair daily activities and athletic performance [5].

With the continuous advancement of medical technology, arthroscopic ATFL repair and reconstruction has become an effective method for the treatment of ATFL injury. The operation offers several advantages, including reduced trauma, faster recovery, and fewer complications, ultimately leading to less pain and improved quality of life for patients [6, 7]. However, the recovery of ankle function post-surgery is a complex and lengthy process influenced by various factors, beyond the surgery itself [8].

Body mass index (BMI) is an important indicator of obesity and is commonly used to distinguish between normal-weight and obese individuals. Recent studies have shown that BMI is closely related to the effect of postoperative rehabilitation [9]. Thès et al. [10] found that high BMI and

https://doi.org/10.62347/NRVX8467

high-intensity exercise were associated with a higher risk of ligament repair failure. BMI not only correlates with body weight and height but also serves as an indirect measure of body fat and muscle mass. In orthopedics, obese patients have high body fat content and high joint load. In knee and hip replacement surgery, obesity is linked to increased surgical difficulty and a higher incidence of complications, such as postoperative infection, thrombosis, and prosthesis loosening, which negatively affect surgical outcomes and rehabilitation [11-13]. For arthroscopic ATFL repair, the high body fat content in obese patients brings excessive ankle joint load, accelerates cartilage wear, and is often accompanied by muscle weakness and poor blood circulation. These factors can impede blood supply and nutrition delivery to the damaged tissues, compromising ligament repair and delaying the recovery of ankle joint function. Furthermore, obesity increases the risk of complications such as postoperative infection and thrombosis, which can interfere with the rehabilitation process [14, 15]. Despite the potential impact of BMI on postoperative rehabilitation after ATFL injury surgery, current research on the correlation between BMI and ankle function rehabilitation is limited, and further studies are needed to explore this correlation in greater depth. This study aims to investigate the correlation between BMI and ankle function recovery following arthroscopic ATFL surgery, providing valuable insights for clinical treatment and rehabilitation strategies.

Materials and methods

Participant information

This study was approved by the Ethics Committee of The First People's Hospital of Jiashan. A total of 106 patients with ATFL injury who underwent arthroscopic ATFL reconstruction at The First People's Hospital of Jiashan from January 2021 to December 2023 were retrospectively included in the study. According to the *2022 Chinese Expert Consensus on Obesity Prevention and Treatment* [16], the patients were divided into three groups based on their BMI: non-overweight group (BMI 18.5-23.9 kg/m^2), overweight group (BMI 24.0-27.9 kg/m^2), and obesity group (BMI > 28.0 kg/m^2).

Inclusion criteria: (1) Diagnosis of CLAI confirmed through X-ray, CT, and MRI examinations; (2) A clear history of ankle joint injury; (3) Unilateral ankle joint injury only; (4) Ineffectiveness of conservative treatments (e.g., ice application, compression bandaging); (5) Ability to tolerate anesthesia and surgical intervention; (6) Indications for arthroscopic ligament augmentation or anterior talofibular ligament repair surgery; (7) Ability to cooperate with follow-up; and (8) Complete clinical data.

Exclusion Criteria: (1) Female patients who are pregnant or breastfeeding; (2) Functional CLAI cases; (3) Presence of concomitant ankle fractures or peripheral infections; (4) Coexisting conditions such as rheumatoid arthritis, osteoporosis, bone tuberculosis, or other bone and joint diseases; (5) Traumatic ankle arthritis; (6) History of previous surgeries on the affected side's ankle joint; (7) Associated nerve or muscle injuries on the affected side; (8) Presence of malignant tumors; (9) Severe dysfunction of vital organs (e.g., liver or kidneys); (10) Mental illness or cognitive impairment, hindering cooperation with the researchers. This study was approved by The First People's Hospital of Jiashan Ethics Committee.

Methods

All patients underwent arthroscopic ATFL repair and reconstruction. Following anesthesia, a thigh tourniquet was applied to the limb. An anteromedial midline approach was utilized, targeting the lateral anterior tibial muscle at the level of the joint line and the medial long extensor tendon for arthroscopy access. Initially, an exploration for any additional lesions within the joint was conducted, after which attention was directed towards the area near the tip of the lateral malleolus. An anterolateral auxiliary approach was established using an 18 G puncture needle positioned anteriorly superior to the tip of the fibula, approximately 1.5 cm above it. Scar tissue and hyperplastic synovium adjacent to the lateral malleolus were carefully debrided, avoiding excessive cleaning to prevent injury to the ATFL stump. The ATFL injury and relaxation were evaluated. A suture anchor (Arthrex, BioComposite SutureTak, 3.0 mm × 14.5 mm) was inserted into the ATFL insertion area at the tip of the lateral malleolus. The ATFL stump was sutured from the outside to the inside using an 18 G puncture needle. One end of the suture was formed into a thread

ring through the ATFL, with the thread tightened to form a self-locking structure, and the other end of the suture was further tightened. The ATFL stump was pulled toward the fibula surface, and the sutures were knotted to fix the ATFL.

Observation index

The primary observation index was the correlation between BMI and postoperative pain, as well as ankle joint function. The secondary observation included the intraoperative indicators and complications after arthroscopic surgery for ATFL injury.

(1) Intraoperative indicators: The operation time and intraoperative blood loss were compared between the two groups. (2) Degree of pain: Visual analogue scale (VAS) [17] was used to evaluate ankle pain before surgery and 6 months post-operation. The score ranged from 0 (no pain) to 10 (worst pain). (3) Ankle function: The American Orthopedic Foot and Ankle Society (AOFAS) score [18] and Carlson Ankle Function Score (KAFS) [19] were used to evaluate ankle function before and 6 months after surgery. The AOFAS score included pain, walking ability, gait, among others, with a total score of 100 points. The KAFS included daily life, ankle swelling, and pain, with a total score of 100 points. Higher scores indicate better ankle function. (4) Complications: Complications were recorded 6 months after surgery, including incision infection, limited varus activity, and lateral stiffness. (5) Correlation: The correlation between BMI and pain degree, as well as ankle function was analyzed.

Statistical methods

SPSS29.0 statistical software was used for data processing. Normality test was used to evaluate the distribution of continuous variables. Continuous variables with normal distribution were presented as mean ± standard deviation (SD), and t-tests were applied. Count variables were presented as [n (%)], with the χ^2 test used for comparison. One-way ANOVA was used to compare data among multiple groups. If significant differences were observed, pairwise comparisons were performed using the LSD method. Pearson's correlation analysis was used for correlation analysis. The significance level was set to $P < 0.05$.

Results

Baseline information

Initially, a total of 118 patients with ATFL injury underwent arthroscopic ATFL reconstruction. After excluding three cases of bilateral ankle joint injury, two cases of anesthesia or surgical treatment intolerance, two cases that did not meet the indications for anterior talofibular ligament repair, two cases of functional CLAI, one case of traumatic ankle arthritis, and two cases with a history of ankle surgery, 106 patients were finally included in this study. Based on BMI, the patients were divided into three groups: non-overweight group (n=46), overweight group (n=39), and obesity group (n=29). The baseline data of the three groups were compared, and no significant differences were observed ($P > 0.05$). The details are shown in **Figure 1** and **Table 1**.

Intraoperative related indicators

No significant differences were observed in the operation time or intraoperative blood loss among the three groups ($P > 0.05$, **Table 2**).

VAS score

The VAS scores during post-operative follow-up showed a significant decrease across all groups. The scores were ranked as follows: non-overweight < overweight < obesity group ($P < 0.05$, **Table 3**), indicating that patients in the obesity group experienced the most server pain among the three groups.

Ankle function score

Before surgery, there were no significant differences in the AOFAS and KAFS scores among the three groups ($P > 0.05$). However, at the 6-month postoperative follow-up, both AOFAS and KAFS scores showed improvement, with the non-overweight group demonstrating the highest scores, followed by the overweight group, and the obesity group having the lowest scores ($P < 0.05$, **Table 4**).

Complications and recurrence rate

The overall incidence of complications in the three groups differed significantly. The non-overweight group had the lowest incidence

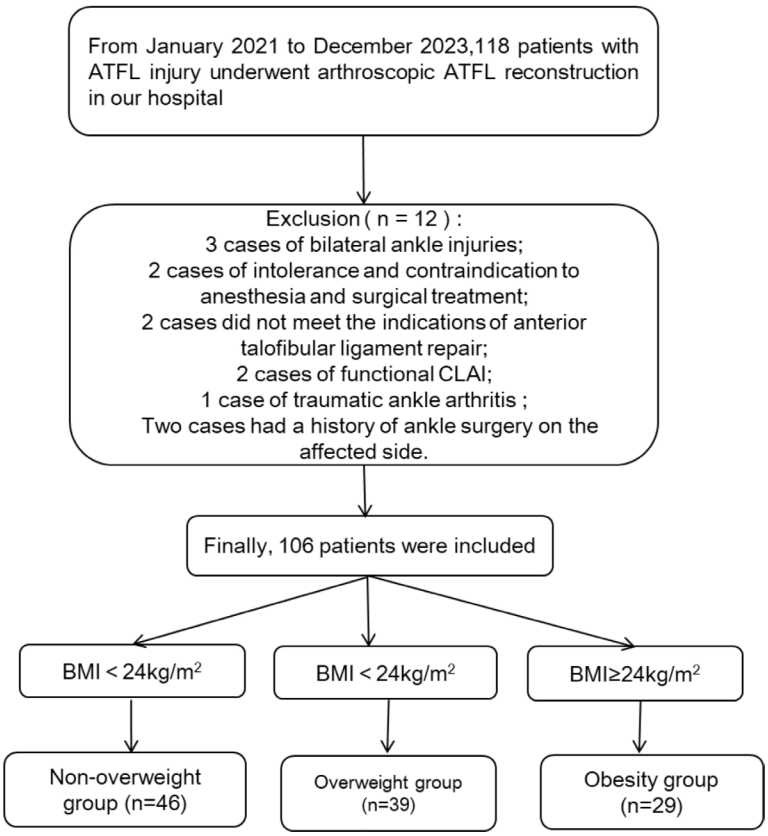

Figure 1. Study flow chart. ATFL, anterior talofibular ligament; CLAI, chronic lateral ankle instability; BMI, body mass index.

(4.35%), followed by the overweight group (17.95%), and the obesity group had the highest incidence (58.62%) ($P < 0.05$, **Table 5**).

Correlation between BMI and postoperative VAS score

Pearson correlation analysis showed that BMI was positively correlated with postoperative VAS score ($r=0.508$, $P < 0.001$, **Figure 2**).

Correlation between BMI and postoperative ankle function score

Pearson correlation analysis showed that BMI was significantly negatively correlated with postoperative AOFAS and KAFS scores ($r=-0.397$, $P < 0.001$; $r=-0.334$, $P < 0.001$, **Figure 3**).

Discussion

Currently, arthroscopic anatomical repair of ATFL injury has gained attention as a promising approach to restoring ankle function. This technique significantly shortens operation time, facilitates intraoperative exploration and treatment of ankle joint lesions, minimizes postoperative swelling and pain, and results in a cosmetically favorable incision. These advantages contribute to early functional exercise and rehabilitation [20]. The results of this study found that there was no significant difference in the intraoperative indicators among the three groups. This is likely due to the standardization of arthroscopic surgery, minimizing variations in surgical performance.

Evidence suggests a strong association between higher BMI and increased joint pain, with morbidly obese patients being flour times more likely to report significant pain compared to non-obese patients [21]. Although there is considerable evidence that there is a link between joint pain and obesity [15, 22-24], there is little literature on the association between BMI and ankle function recovery and rehabilitation in patients with ATFL after arthroscopic surgery. The results of this study align with those findings, revealing that the postoperative VAS scores were significantly higher in the obesity group compared with the non-overweight and overweight groups. Pearson correlation analysis confirmed a positive correlation between BMI and postoperative VAS score, indicating that while arthroscopic surgery effectively reduces pain, patients with higher BMI tend to experience more intense postoperative pain. Several mechanisms may explain these findings [25, 26]: (1) A higher BMI indicates that patients have greater body weight, which significantly increases the mechanical stress on the ankle joint during daily activities. Following arthroscopic repair of anterior talofibular ligament injuries, the newly formed ligament tissue and repair site are more susceptible to micro-damage, tissue fatigue, and inflammatory responses under sustained high-load pressure, leading to exacerbated

Table 1. Comparison of baseline data among the three groups of patients

Groups	Non-overweight group (n=46)	Overweight group (n=39)	Obesity group (n=29)	F/χ^2	P
Sex				2.242	0.326
Male	27 (58.70)	27 (69.23)	15 (51.72)		
Female	19 (41.30)	12 (30.77)	14 (48.28)		
Age (years)	39.04±6.93	36.87±7.07	36.66±7.68	1.374	0.257
Course of disease (months)	4.72±0.62	4.88±0.58	4.71±0.59	0.968	0.383
Affected side				0.015	0.993
Right	26 (56.52)	22 (56.41)	16 (55.17)		
Left	20 (43.48)	17 (43.59)	13 (44.83)		
Cause of injury				1.990	0.754
Traffic accidents	11 (23.91)	12 (30.77)	9 (23.08)		
Sports sprain	23 (50.00)	21 (53.85)	15 (51.72)		
Daily activities	12 (26.09)	6 (15.38)	5 (17.24)		

Table 2. Comparison of intraoperative parameters among the three groups

Group	Operation time (min)	Intraoperative blood loss (mL)
Non-overweight group (n=46)	50.87±1.88	40.17±4.24
Overweight group (n=39)	52.36±3.41	41.85±4.61
Obesity group (n=29)	51.69±3.24	40.07±4.33
F	2.930	1.954
P	0.058	0.147

Table 3. Comparison of VAS scores among the three groups of patients

Group	Preoperative	Postoperative
Non-overweight group (n=46)	6.87±1.54	2.57±0.66*
Overweight group (n=39)	7.08±1.46	3.33±0.93*
Obesity group (n=29)	7.00±1.67	3.76±0.95*
F	0.195	19.925
P	0.833	< 0.001

Note: *$P < 0.05$, compare with preoperative value; VAS, visual analogue scale.

pain. Additionally, excess weight contributes to increased wear on articular cartilage and surrounding soft tissues, stimulating nerve endings and triggering pain. (2) Obese patients often experience metabolic disorders such as insulin resistance and abnormal secretion of adipokines. Adipose tissue secretes various pro-inflammatory cytokines (e.g., tumor necrosis factor-alpha, interleukin-6), which can directly affect the injury repair site by inhibiting the healing process, prolonging inflammation duration, and intensifying pain perception. Furthermore, metabolic dysregulation may also impact neural conduction and nociceptive modulation mechanisms, increasing patients' sensitivity to pain. (3) Patients with a higher BMI face additional challenges during postoperative rehabilitation. Due to their larger body weight, joints endure greater stress during rehabilitation exercises; thus patients may struggle to perform prescribed rehabilitation movements correctly. This difficulty can delay recovery progress and lead to poor restoration of joint function - resulting in persistent or aggravated pain. Moreover, wound healing in obese patients post-surgery may be compromised due to increased infection risk; should an infection occur it could further irritate surrounding tissues and exacerbate pain. Therefore, clinicians should fully consider BMI of patients when formulating rehabilitation programs after arthroscopic surgery for ATFL injury and develop more targeted rehabilitation strategies for patients with higher BMI to reduce postoperative pain and improve rehabilitation effects.

In this study, patients in the obesity group demonstrated significantly lower AOFAS and KAFS scores compared to the normal weight group and the overweight group, indicating worse

Table 4. Comparison of ankle function scores among the three groups of patients

Group	AOFAS score (points)		KAFS score (points)	
	Preoperative	Postoperative	Preoperative	Postoperative
Non-overweight group (n=46)	58.83±6.56	86.02±5.39*	58.89±4.16	82.26±3.80*
Overweight group (n=39)	56.41±9.73	83.00±4.87*	59.87±3.69	80.54±3.65*
Obesity group (n=29)	76.72±10.37	79.97±5.94*	60.34±4.66	78.34±5.10*
F	0.939	11.535	1.225	8.063
P	0.394	< 0.001	0.298	< 0.001

Note: *$P < 0.05$, compare with preoperative value; AOFAS, American Orthopedic Foot and Ankle Society; KAFS, Carlson ankle function score.

Table 5. Comparison of complication incidence among the three groups

Group	Inversion activity is limited	Wound infection	The ligament broke again	Lateral stiffness	Vascular nerve injury	The total incidence of complications (%)
Non-overweight group (n=46)	1 (2.17)	1 (2.17)	0 (0.00)	0 (0.00)	0 (0.00)	2 (4.35)
Overweight group (n=39)	2 (5.12)	1 (2.56)	0 (0.00)	1 (2.56)	3 (7.69)	7 (17.95)
Obesity group (n=29)	4 (13.79)	5 (17.24)	2 (6.90)	2 (6.90)	4 (13.79)	17 (58.62)
χ^2						30.553
P						< 0.001

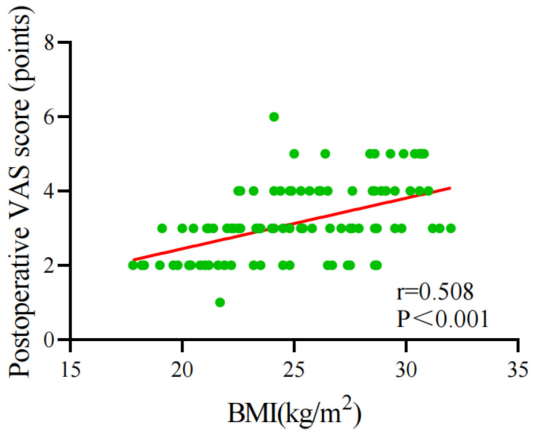

Figure 2. Correlation analysis between BMI and postoperative VAS score. BMI, body mass index; VAS, visual analogue scale.

functional recovery. These results are consistent with other studies examining the impact of BMI on recovery after surgeries involving tendon grafts. Koh et al. [27] found that the AOFAS and PCS scores of the normal BMI group and the overweight and obese group were significantly improved at 6 months and 24 months after operation. The VAS, AOFAS and PCS scores of the two groups were compared before operation, 6 months after operation and 24 months after operation. During postoperative follow-up, AOFAS score and KAFS score showed an increase, with the best recovery observed in non-overweight group, followed by overweight and obesity groups. Pearson correlation analysis showed that BMI was negatively correlated with postoperative AOFAS and KAFS scores, suggesting that the higher the BMI, the worse the ankle function recovery and rehabilitation effect. This could be attributed to several factors: (1) The added load from excess body weight places additional stress on the ankle joint during the recovery phase. This continuous high load compromises blood circulation to the area, impairing nutrient delivery and delaying ligament and tissue healing. As a result, recovery may be prolonged, and functional outcomes may be compromised. (2) Obesity is often accompanied by metabolic and endocrine system disorders, which can negatively affect the regeneration of damaged tissues and delay the healing process, ultimately impairing functional recovery [11, 28, 29]. (3) Obese patients face greater physical challenges during postoperative rehabilitation exercises. Excess weight may limit their ability to perform certain movements, thereby reducing the effectiveness of rehabilitation and slowing recovery. In conclusion, BMI closely associated with ankle functional recovery and rehabilitation of patients after arthroscopic surgery. Multiple factors, including increased joint load, systemic inflammation, metabolic abnormalities,

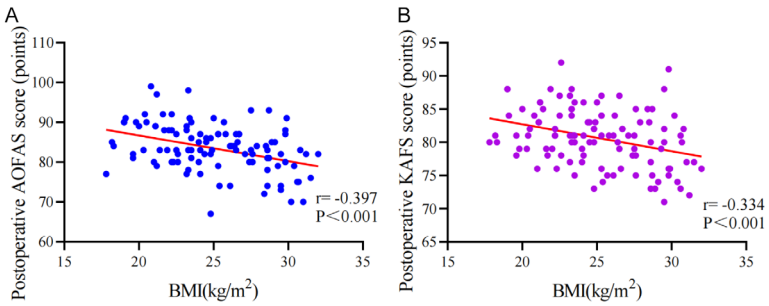

Figure 3. Correlation analysis between BMI and postoperative AOFAS and KAFS scores. A: The correlation between BMI and postoperative AOFAS score; B: The correlation between BMI and postoperative KAFS score. AOFAS, American orthopedic foot and ankle society; KAFS, Carlson ankle function score; BMI, body mass index.

and challenges in rehabilitation, contribute to the suboptimal outcomes observed in obese patients.

Obesity is associated with an increased incidence of early complications following arthroscopic surgery. Nicolay et al. [30] studied 14,335 patients in a database that evaluated hip, knee and shoulder arthroscopic complications, and found that higher BMI, particularly in grade III obese patients, is associated with an increased incidence of complications after arthroscopic surgery. Similarly, our study demonstrated a clear gradient in the incidence of postoperative complications across the three BMI groups, with the non-overweight group experiencing the lowest rate (4.35%), the overweight group having a moderate rate (17.95%), and the obesity group showing the highest rate (58.62%). This suggests that obesity significantly increases the risk of postoperative complications, likely due to the increased mechanical burden placed on the joint and the systemic effects of obesity, including metabolic and inflammatory disturbances.

This study has certain limitations: (1) the sample size is relatively small and the follow-up period is short, which may lead to potential information bias; (2) the assessment of ankle joint function using AOFAS and KAFS scores relies on subjective measures, making it susceptible to individual variability. Therefore, future research should aim to increase the sample size and implement longitudinal, multicenter, and prospective study designs for further exploration.

In summary, BMI is closely related to postoperative pain, ankle function recovery, and the overall rehabilitation effect in patients with ATFL injuries undergoing arthroscopic surgery. Higher BMI is associated with increased pain, poorer functional outcomes, and a higher incidence of complications.

Disclosure of conflict of interest

None.

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