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RESEARCH

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All-inside arthroscopic repair of ATFL and CFL separately for chronic lateral ankle instability in conjunction with subtalar instability

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Abstract

Background Chronic lateral ankle instability (CLAI) is a common condition often associated with damage to the anterior talofibular ligament (ATFL). In cases where CLAI is accompanied by subtalar instability (STI) due to calcaneofibular ligament (CFL) injury, the optimal surgical approach remains controversial. While isolated ATFL repair has been shown to effectively restore ankle joint stability, it may be insufficient to address the subtalar joint instability caused by CFL damage. This study aimed to evaluate the clinical importance of CFL repair by comparing the outcomes of isolated ATFL repair versus combined ATFL and CFL repair.

Methods A retrospective cohort study was conducted involving patients diagnosed with CLAI in conjunction with STI from January 2018 to January 2022. Participants were divided into two groups: one underwent isolated ATFL repair (ATFL group), and the other underwent combined ATFL and CFL repair (ATFL + CFL group). Clinical outcomes were assessed using the American Orthopaedic Foot & Ankle Society Ankle-Hindfoot Scale (AOFAS-AH), Karlsson Ankle Functional Score (KAFS) and Visual Analog Scale (VAS) scores, while radiological outcomes were evaluated by MRI and stress radiographs.

Results All the functional scores significantly improved in both groups post-surgery. However, the ATFL + CFL group demonstrated superior functional recovery, with higher AOFAS scores and greater reductions in VAS pain scores compared to the ATFL group. Radiological evaluation indicated better restoration of subtalar joint stability in the ATFL + CFL group. At the final follow-up, 3 cases of recurrent instability were observed in the isolated ATFL repair group. No significant difference in other complication rates was observed between the two groups.

Conclusion The study demonstrated the importance of CFL repair in patients with CLAI in conjunction with STI. While isolated ATFL repair is effective for ankle joint stability, combined ATFL and CFL repair offers superior outcomes by addressing both ankle and subtalar joint instability. These findings suggest that CFL repair should be considered in surgical planning for patients with STI to optimize functional recovery and long-term stability.

Level of evidence Level III.

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Keywords Subtalar instability, Chronic lateral ankle instability, Anterior talofibular ligament, Calcaneofibular ligament, Arthroscopic

Introduction

Chronic lateral ankle instability (CLAI) is one of the most common injuries in sports medicine, with a high incidence in both athletes and the general population [1–3]. It is primarily associated with damage to the anterior talofibular ligament (ATFL) [4, 5]. However, studies have shown that approximately 20–25% of patients with acute ankle sprains or chronic lateral instability also experience injury to the calcaneofibular ligament (CFL) [6, 7]. As an essential component of the lateral ligament complex, the CFL plays a critical role in maintaining stability not only at the ankle joint during dorsiflexion but also in providing dynamic stability to the subtalar joint [8–10]. Biomechanically, the CFL spans both the ankle and subtalar joints, functioning as a key stabilizer against excessive inversion and rotational forces [11]. Therefore, damage to the CFL may therefore compromise the structural integrity of both joints, resulting in not only ankle instability but also subtalar instability (STI) [12].

For cases of isolated CLAI, arthroscopic repair of the ATFL alone has typically achieved satisfactory clinical outcomes. Numerous studies have confirmed that isolated ATFL repair can effectively alleviate symptoms and improve joint function, with additional CFL repair having no significant effect on the overall outcome [13–17]. However, this perspective lacks consideration of subtalar stability. The inferior fascicle of the ATFL and the CFL are connected by fibers, so repairing the ATFL can partially tension the CFL [18, 19]. However, this repair is insufficient to fully tighten the CFL, particularly when the ligament is extremely lax, which is an important reason why some patients keep complaining of their hindfoot instability after ankle stabilization surgery [20, 21]. In this context, the necessity of CFL repair remains a key clinical question.

This study aims to evaluate whether combined repair of the ATFL and CFL offers superior outcomes compared to isolated ATFL repair in patients with CLAI accompanied by STI. We propose the following hypotheses: (1) Simply repairing the ATFL cannot restore STI. (2) Separately repairing the ATFL and CFL can simultaneously reconstruct the stability of the ankle and subtalar joints.

Methods

A retrospective analysis was conducted on patients who underwent arthroscopic ligament repair surgery for CLAI combined with STI between January 2018 and January 2022. This study was approved by the ethics committee of our hospital. Written informed consent was obtained from all patients. All surgeries were performed by the same surgeon. Surgical indications for this procedure included patients who presented with a history of recurrent lateral ankle sprains and demonstrated persistent symptoms of instability despite at least 6 months of non-operative treatment (physical therapy, bracing, and non-steroidal anti-inflammatory drugs). These patients typically experienced frequent ankle sprains (3 or more episodes over the past 12 months) and exhibited signs of both ankle and subtalar joint instability, as confirmed by clinical tests (positive anterior drawer and inversion stress tests) and radiographic imaging (positive subtalar stress radiographs) [22]. Furthermore, MRI findings of ligamentous damage in both the ATFL and CFL were essential for confirming the need for surgical intervention.

Patient selection

The criteria included in our study were as follows: (1) Patients with CAI combined with STI who underwent arthroscopic treatment after failed non-surgical treatment, (2) Patients who completed a ≥ 2-year postoperative follow-up with complete clinical evaluation data.

The exclusion criteria were as follows: (1) previous surgery of the affected limb, (2) lateral malleolar fracture on the affected side, (3) significant bone deformities in the affected ankle or foot, (4) poor ligament quality during surgery that was not suitable for repair, (5) chronic ankle osteoarthritis, (6) BMI > 30, and (7) abnormalities of the interosseous talocalcaneal ligament (ITCL) and/or cervical ligament (CL) on MRI.

Group division

Patients were divided into two groups based on whether additional CFL repair was performed following arthroscopic ATFL repair for CLAI combined with STI: ATFL group underwent arthroscopic ATFL repair alone, while ATFL + CFL group underwent arthroscopic ATFL repair with additional CFL repair. Between January 2018 and June 2020, patients with CLAI combined with STI were treated exclusively with isolated arthroscopic ATFL repair. After July 2020, combined arthroscopic ATFL and CFL repair was adopted. The reason for this procedural change was concern that isolated ATFL repair might be insufficient to restore subtalar joint stability. To ensure subtalar joint stability and improve the long-term outcomes of surgery, the all-inside arthroscopic combined ATFL and CFL repair technique was used after July 2020.

Operative technique

The patient was positioned in the supine position, with an inflatable tourniquet applied to the proximal thigh for hemostasis. Four arthroscopic portals were marked on the skin. The P1 portal was located approximately 1 cm proximal to the ankle joint line and just lateral to the anterior tibial tendon. This portal served as the viewing portal. The P2 portal was located approximately 1 cm distal to the ankle joint line and just lateral to the peroneus tertius tendon. This portal could be used both as the working and viewing portal. The P3 portal was located at the tarsal sinus and could also be used interchangeably as both the working and the viewing portal. The P4 portal is located adjacent to the tip of the lateral malleolus and was used as the accessory portal for CFL repair. (Fig. 1). Diagnostic arthroscopy was performed through the P1 portal to debride the hyperplastic synovium and intra-articular scar tissue, with concomitant lesions treated simultaneously.

Arthroscopic Anatomic ATFL Repair. After debridement of the ATFL footprint area of the lateral malleolus, a 4.0-mm, 30° arthroscope (Smith & Nephew, London, UK) was introduced into the ankle joint through the P2 portal. A probe was then used through the P3 portal to explore and confirm the significant laxity of the ATFL. (Fig. 2A). A 3.0-mm absorbable suture anchor (Smith & Nephew, London, UK) was inserted into the debrided ATFL footprint on the fibula using the P3 portal (Fig. 2B). The SutureLasso (Arthrex, Naples, FL) was inserted through the P3 portal from the lower lateral to the upper medial side of the ATFL (Fig. 2C). The wire loop was retrieved from the P3 portal with a grasper and

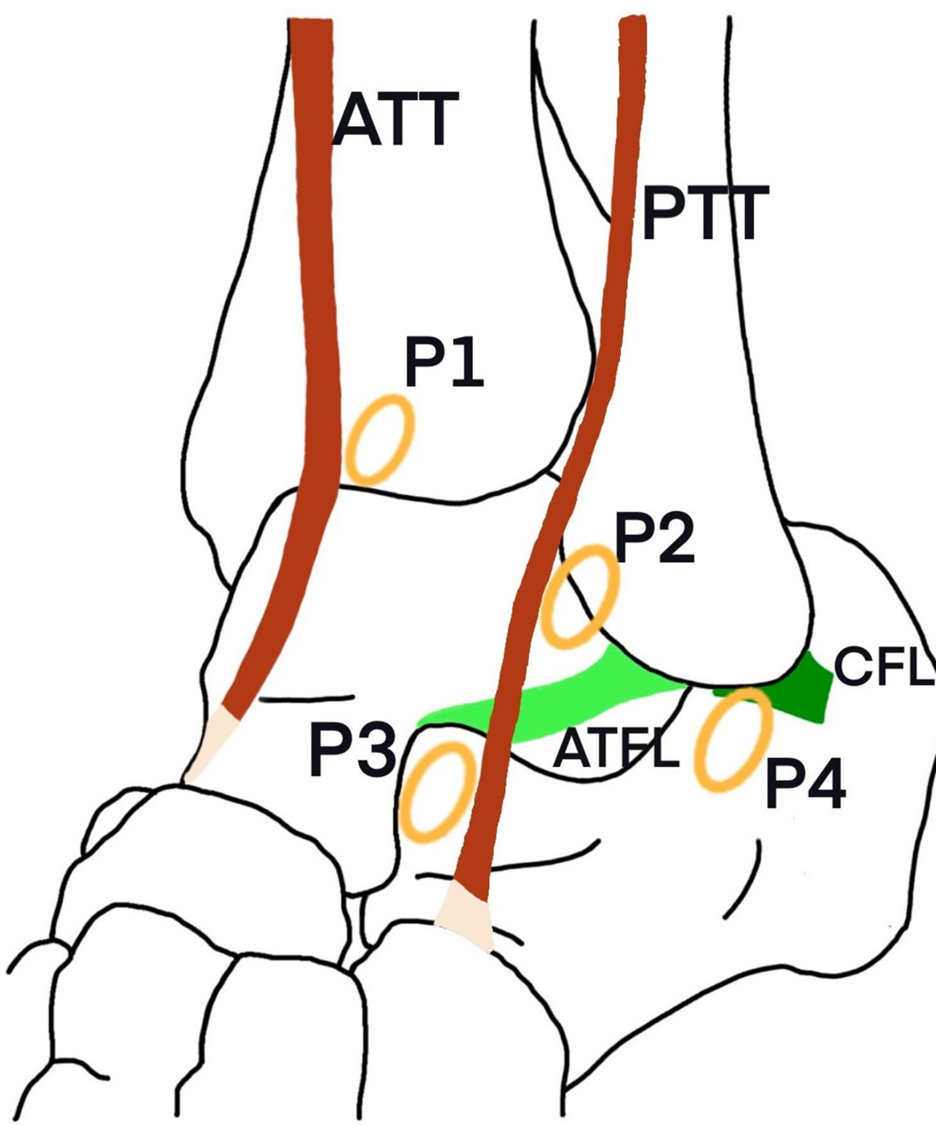

Fig. 1 Schematic drawing illustrated arthroscopic portals on skin landmarks. ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; ATT, anterior tibial tendon; PTT, peroneus tertius tendon

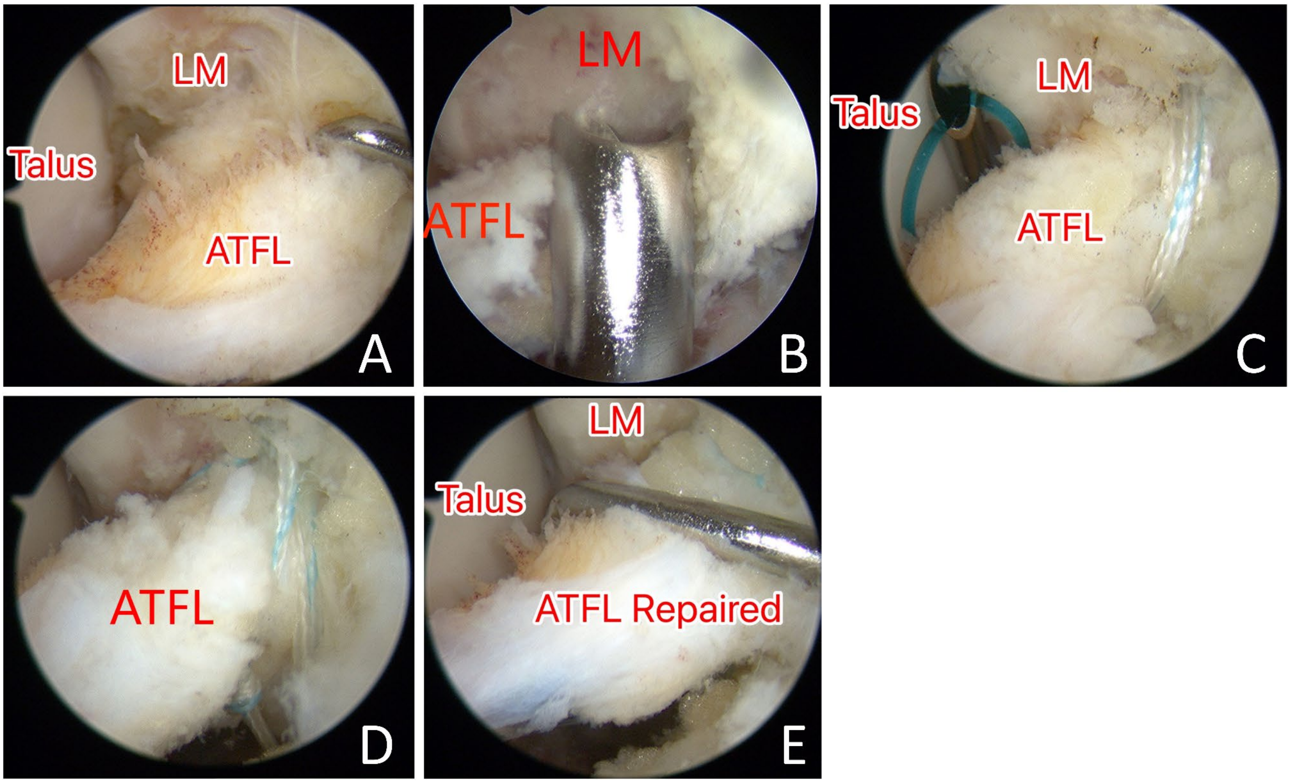

Fig. 2 Intraoperative images of ATFL repair. A debridement and freshening of the ATFL footprint, revealing laxity. B the anchor placement in the distal lateral malleolus footprint. C the suturing process of the ATFL. D tension adjustment and knot tying. E confirms satisfactory ATFL tension using a probe. ATFL, anterior talofibular ligament; LM, lateral malleolus

passed through one suture. Then, the SutureLasso was withdrawn through the upper medial to the lower lateral direction, following the same approach. The wire loop of the SutureLasso pulled the thread of the suture out of the P3 portal from the midportion (Fig. 2D). The end of the suture was passed through its own midportion to form a loop, then locked with a slip-knot technique (Fig. 2E).

Additional CFL Repair. After ATFL anatomic repair, switched to the P2 and P4 portal as the working portal and the P3 portal as the viewing portal, the tarsal sinus was debrided as well through the P2 portal, exposing the distal joint, ITCL, and CL. The ITCL was identified as normal with the probe (Fig. 3A), ruling out rotational instability of the subtalar joint. Dissection was then performed along the medial side of the peroneal tendons to expose the CFL. The probe was used to assess the integrity and relaxation of the CFL and the posterior articular surface of the subtalar joint through the P4 portal, both of which were confirmed to be lax, further indicating subtalar instability (Fig. 3B-C). A 3.0-mm absorbable suture anchor was inserted at the CFL footprint on the calcaneus using the P4 portal (Fig. 3D). The CFL was tightened using the same method as previously described (Fig. 3E-G).

The patient was immobilized in a neutral position with a short leg cast for 3–4 weeks. Physical therapy and range of motion exercises were initiated 6 weeks postoperatively. Additionally, the patient engaged in ankle joint proprioceptive training for 2–3 months.

Clinical evaluations

The assessment of clinical outcomes included preoperative and during the final follow-up (at least 24 months postoperatively) evaluations using the Visual Analog Scale (VAS), American Orthopaedic Foot & Ankle Society Ankle-Hindfoot Scale (AOFAS-AH), and the Karlsson Ankle Functional Score (KAFS) [23].

Radiographic evaluations

Stress Radiography. All patients underwent preoperative weight-bearing anteroposterior, lateral radiographs of the foot and ankle, as well as hindfoot alignment views to investigate the presence of malalignment [24, 25]. Stress radiographs were recorded using a Telos device (Telos GmbH, Marburg, Germany) at both preoperative and final follow-up evaluations (Fig. 4). Standardized methods were used for all stress radiographs, measuring the talar tilt angle and anterior talar translation to assess ankle stability, as well as the subtalar tilt angle and

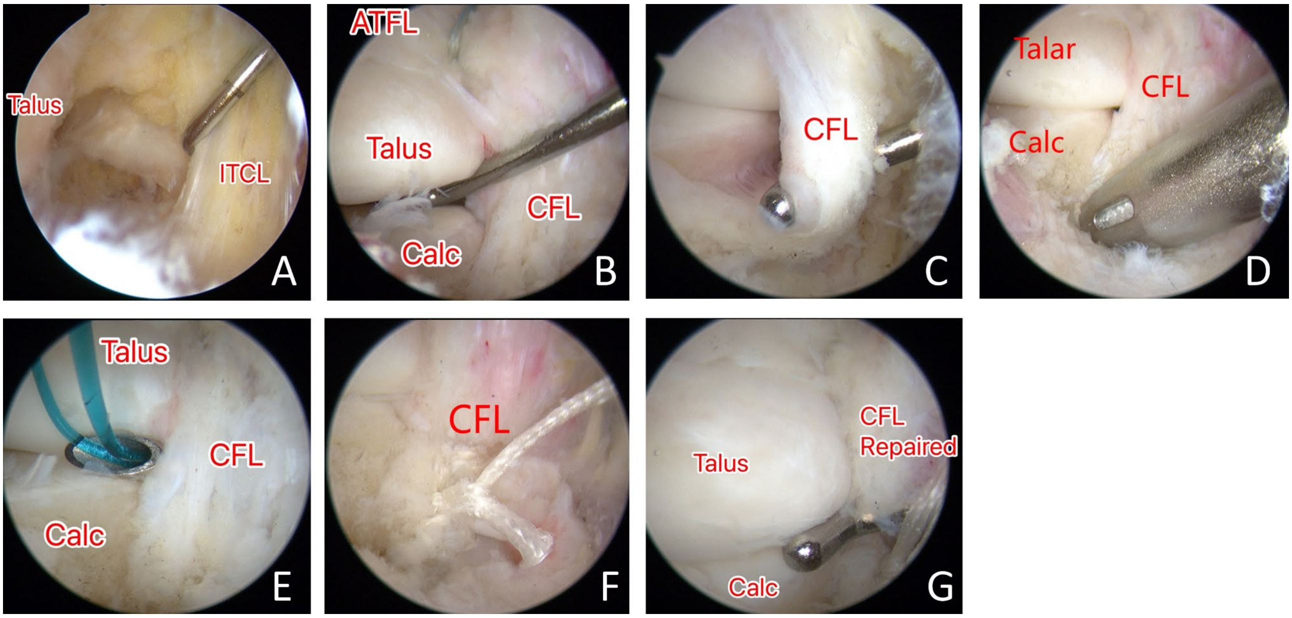

Fig. 3 Intraoperative images of CFL repair. **A** show that the ITCL is normal. **B** probe insertion into the posterior subtalar joint surface. **C** shows that the CFL is relaxed. **D** anchor placement at the CFL calcaneal footprint. **E** the suturing process of the CFL. **F** CFL tension adjustment and knot tying. **G** after CFL repair, the posterior joint surface of the subtalar joint closed. ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; ITCL, interosseous talocalcaneal ligament

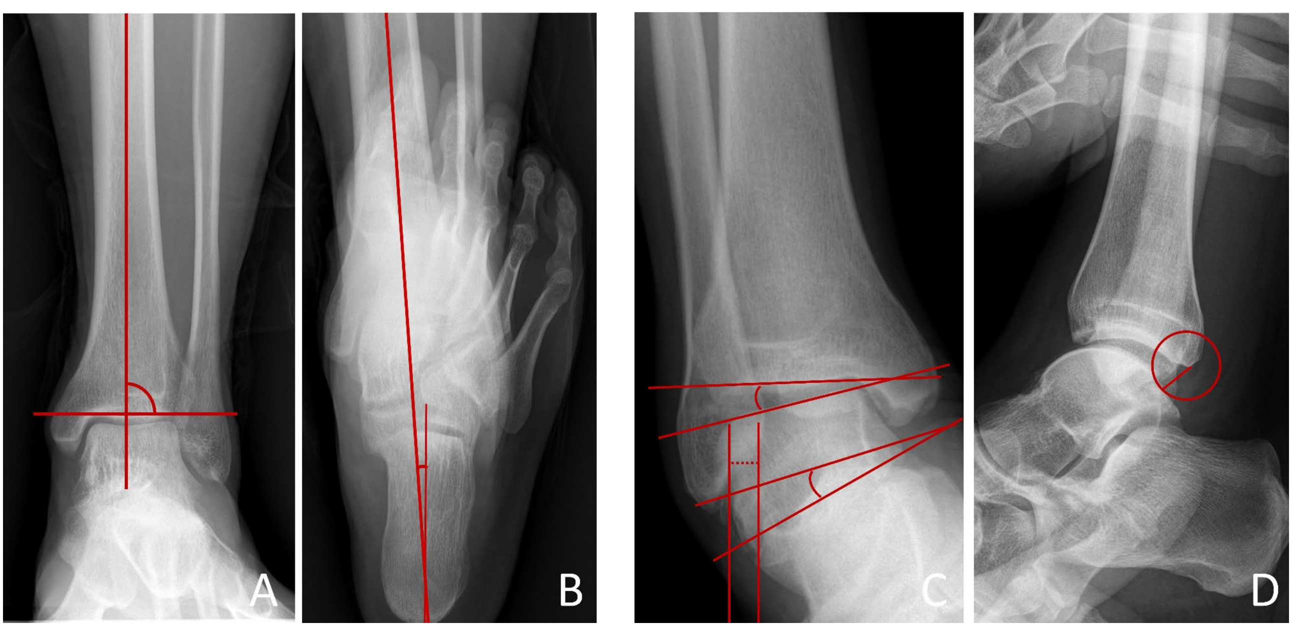

Fig. 4 Preoperative radiographs of the patient. **A** weight-bearing anteroposterior view. **B** hindfoot long-axis view, both confirming normal alignment. **C** Broden's stress view, showing increased talar and subtalar tilt angles and calcaneal medial translation. **D** anterior drawer stress radiograph, revealing anterior translation of the talus

calcaneal medial translation to evaluate subtalar joint stability. All measurements were conducted using a digital Neusoft PACS/RIS imaging system by two orthopedic surgeons, and the results were averaged for accuracy.

MRI Scan. All patients were performed with a 1.5-T MRI scanner (Artoscan, Esca, Gscan) preoperatively and at the one-year postoperative follow-up to confirm ligament integrity (Fig. 5). The normal ATFL is identified as a linear, thin, low-signal-intensity band on T1-weighted axial images [26]. The CFL is identified as a round, uniform, low-signal-intensity structure on cross-sectional images [27]. According to the criteria proposed by Joshy et al. [28] chronic ligament tears or dysfunction were diagnosed if the ligament appeared invisible,

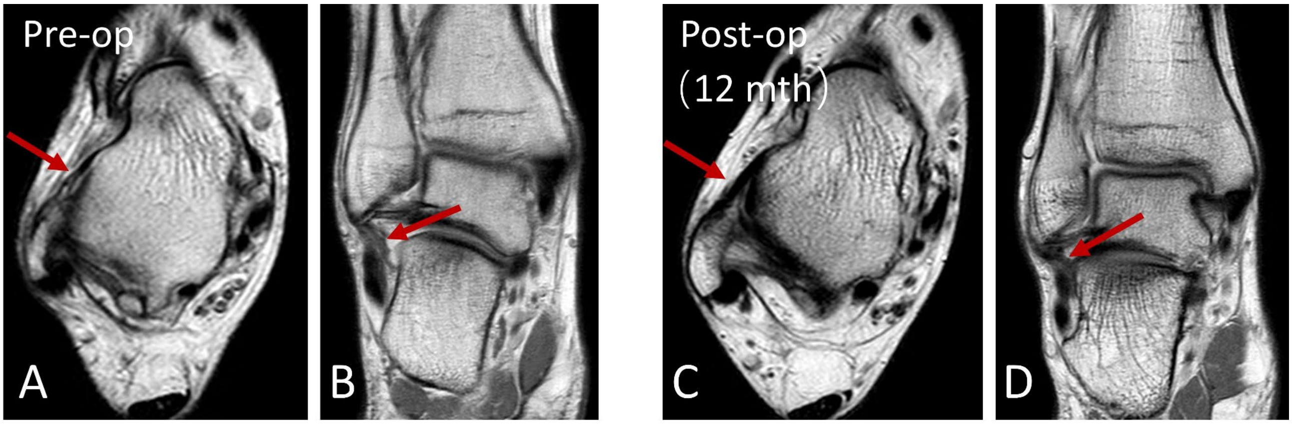

Fig. 5 A 25-year-old male presented with a sprained right ankle. (**A, B**) The preoperative axial T2-weighted and coronal PDW images showed that the ATFL was partially torn, appeared slender and incomplete, and the CFL appears thicker and blurred (arrows). (**C, D**) The axial T2-weighted and coronal PDW images at the 12-month postoperative follow-up showed that the ATFL and CFL had grown well with well-defined structures (arrows). ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament

Table 1 Demographic characteristics of the patients.[a]

Demographics	ATFL repair (*n* = 14)	ATFL + CFL repair (*n* = 16)	*P* Value
Age, y, mean ± SD	33.4 ± 6.3	31.7 ± 4.5	0.734
Sex: male, n (%)	8 (57.1)	10 (62.5)	0.626
BMI, mean ± SD	23.2 ± 2.3	22.9 ± 2.1	0.887
Side: left, n (%)	5 (55.6)	8 (50.0)	0.854
Symptom duration, mo, mean ± SD	25.4 ± 3.8	27.8 ± 4.2	0.768
Follow-up, mo, mean ± SD	24.3 ± 4.3	24.5 ± 3.9	0.943
Concomitant intra-articular lesions, n (%)	3 (21.4)	4 (25.0)	0.748
Osteochondral lesion	2 (14.2)	3 (18.8)	0.629
Loose body	2 (14.3)	4 (25.0)	0.128
Osteophytes	4 (28.6)	5 (31.2)	0.726
Subfibular ossicle			

[a]Categorical variables are reported as n (%). Continuous variables are reported as mean ± SD. Abbreviations: BMI, body mass index

discontinuous, or had a wavy or curved contour. Ligaments showing uniform low-signal intensity on imaging were considered normal.

Statistical analysis

All statistical analyses were performed using SPSS (version 22.0; SPSS Inc, Chicago, IL). The Shapiro-Wilk test was used to evaluate the normality of the data distribution. Continuous variables following a normal distribution were analyzed using an unpaired *t*-test, while the Mann-Whitney *U* test was applied for variables that did not meet normality assumptions. Paired data were analyzed using a paired *t*-test or Wilcoxon signed-rank test as appropriate. $P<.05$ was considered indicative of statistical significance.

Results

Patient characteristics

From January 2018 to January 2022, 35 patients with CLAI combined with STI were treated with arthroscopic ligament repair surgery at our hospital.1 case were excluded due to ankle fractures; 2 case underwent ligament reconstruction surgery due to poor ligament quality observed during surgery; 1 case had osteoarthritis and osteochondritis; and 1 case had a follow-up period of less than two years. Eventually, a total of 30 patients were included in the study and divided into two groups based on whether additional CFL repair was performed under arthroscopy: the isolated ATFL repair group ($n=14$) and the ATFL + CFL repair group ($n=16$). The baseline characteristics of the patients between the two groups showed no significant differences ($P>.05$, Table 1).

Clinical outcomes

The VAS scores, AOFAS-AH scores, and Karlsson-Peterson scores showed significant improvement at 12 months postoperatively and at the final follow-up in both groups compared to preoperative values ($P<.01$, Table 2). At 12 months, the ATFL + CFL repair group demonstrated significantly lower VAS scores (2.4 ± 0.6 vs. 3.5 ± 0.4) and higher AOFAS-AH scores (85.4 ± 7.2 vs. 76.8 ± 4.7) and Karlsson-Peterson scores (83.2 ± 10.8

Table 2 Functional outcomes comparison of the two groups. [a]

Functional Outcomes	ATFL repair (*n* = 14)	ATFL + CFL repair (*n* = 16)	*P* Value
Visual analog scale			
Preoperative	6.4 ± 1.2	6.7 ± 2.3	0.354
12 mo	3.5 ± 0.4	2.4 ± 0.6	< 0.01
Final follow-up	2.8 ± 0.7	2.2 ± 0.4	< 0.05
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	
Karlsson-Peterson scores			
Preoperative	45.2 ± 7.3	42.1 ± 8.7	0.673
12 mo	74.4 ± 6.8	83.2 ± 10.8	< 0.01
Final follow-up	77.8 ± 9.1	85.6 ± 5.9	< 0.01
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	
AOFAS-AH			
Preoperative	55.3 ± 7.1	57.8 ± 8.4	0.735
12 mo	76.8 ± 4.7	85.4 ± 7.2	< 0.01
Final follow-up	78.1 ± 8.2	88.5 ± 2.9	< 0.01
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	

Continuous variables are reported as mean ± SD. Abbreviations: AOFAS-AH, American Orthopaedic Foot & Ankle Society Ankle-Hindfoot Scale

Table 3 Radiological outcomes comparison of the two groups

Radiological Outcomes	ATFL repair (*n* = 14)	ATFL + CFL repair (*n* = 16)	*P* Value
Talar tilt angle, degrees			
Preoperative	12.3 ± 2.1	11.9 ± 3.7	0.734
12 mo	6.2 ± 1.3	4.4 ± 0.9	< 0.05
Final follow-up	6.7 ± 0.7	4.3 ± 0.6	< 0.01
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	
Anterior talar translation, mm			
Preoperative	11.8 ± 1.3	12.0 ± 0.8	0.875
12 mo	5.3 ± 0.7	5.4 ± 1.2	0.641
Final follow-up	5.4 ± 1.0	5.3 ± 1.1	0.548
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	
Subtalar tilt angle, degrees			
Preoperative	11.3 ± 2.5	11.5 ± 2.4	0.735
12 mo	7.8 ± 1.7	4.1 ± 1.3	< 0.01
Final follow-up	8.1 ± 2.2	4.2 ± 2.1	< 0.01
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	
Medial calcaneal translation, mm			
Preoperative	9.3 ± 2.7	9.1 ± 1.3	0.817
12 mo	5.8 ± 2.7	2.7 ± 1.4	< 0.01
Final follow-up	6.1 ± 2.5	2.7 ± 0.8	< 0.01
P value (preoperative vs. 12 mo)	< 0.01	< 0.01	

Continuous variables are reported as mean ± SD

vs. 74.4 ± 6.8) compared to the ATFL repair-only group ($P<.01$). This trend persisted at the final follow-up, with the ATFL + CFL group showing superior VAS (2.2 ± 0.4 vs. 2.8 ± 0.7), AOFAS-AH (88.5 ± 2.9 vs. 78.1 ± 8.2), and Karlsson-Peterson scores (85.6 ± 5.9 vs. 77.8 ± 9.1) ($P<.01$). These results indicate that although both groups achieved substantial improvements, the ATFL + CFL repair group consistently exhibited better pain relief and functional recovery.

Radiographic outcomes

The radiological outcomes demonstrated significant improvements in both groups after surgical treatment (Table 3). Talar tilt angle (TTA), subtalar tilt angle (STA), and medial calcaneal translation (CMT) were significantly reduced at 12 months postoperatively and at the final follow-up compared to preoperative values ($P<.01$). However, the ATFL + CFL repair group exhibited superior radiological outcomes compared to the ATFL repair-only group. At 12 months, the TTA was significantly lower in the ATFL + CFL group (4.4 ± 0.9°) compared to the ATFL-only group (6.2 ± 1.3°) (P<.05), and this difference further widened at the final follow-up (4.3 ± 0.6° vs. 6.7 ± 0.7°, P<.01). Similarly, the STA at 12 months was substantially reduced in the ATFL + CFL group (4.1 ± 1.3°) compared to the ATFL-only group (7.8 ± 1.7°, P<.01), with this trend persisting at the final follow-up (4.2 ± 2.1° vs. 8.1 ± 2.2°, P<.01). Moreover, the CMT was markedly lower in the ATFL + CFL group (2.7 ± 1.4 mm) at 12 months compared to the ATFL-only group (5.8 ± 2.7 mm, P<.01), and this significant difference remained at the final follow-up (2.7 ± 0.8 mm vs. 6.1 ± 2.5 mm, P<.01). There was no statistically significant difference in the anterior talar translation (ATT) in two groups at any time point (P>.05). At the one-year postoperative follow-up, MRI scans demonstrated successful ligament healing in both groups. The ATFL was visualized as a well-defined, linear structure with low signal intensity on T1-weighted axial images, while the CFL appeared as a consistent, rounded, low-signal-intensity band in cross-sectional views (Figs. 5C-D).

Recurrence and other complications

All patients had no incision-related complications, no nerve damage. However, at the final follow-up, 3 cases of recurrent instability with increased pain symptoms occurred in the isolated ATFL repair group, which later underwent ligament reconstruction surgery. No cases of recurrent instability were observed in the combined ATFL and CFL repair group.

Discussion

The most important finding of this study is that the combined arthroscopic repair of the ATFL and CFL yielded superior clinical and radiological outcomes compared to isolated ATFL repair in patients with CLAI accompanied by STI. This study demonstrated the importance of addressing subtalar instability in the surgical management of these patients. Failure to adequately treat combined instability of the ankle and subtalar joints may lead to recurrent sprains and hinder optimal functional recovery.

There are many studies that have shown that subtalar instability is often associated with combined injuries to the ITCL, CL, and CFL, while isolated ligament injuries are less common [29, 30]. However, in clinical practice, we have observed a number of cases where STI was caused by isolated CFL injuries. We hypothesize that this may be primarily due to the CFL being the first ligamentous structure injured during the development of subtalar instability, while the ITCL and CL are not yet significantly impacted in the early stages of the condition [8]. The combined failure of the CFL and the ATFL can cause lateral ankle instability in conjunction with subtalar instability [31].

Currently, there is no established method for diagnosing combined lateral instability of the ankle and subtalar joints. In our study, we diagnosed this condition through a comprehensive evaluation using clinical, radiographic, and arthroscopic assessments. First, we performed the anterior drawer and subtalar stress tests for a preliminary assessment. MRI subsequently confirmed injuries to both the ATFL and CFL, while the intrinsic ligaments of the subtalar joint were observed integrity. Initial assessment suggested the potential presence of combined lateral instability of the ankle and subtalar joints. Second, we used stress radiographs to assess lateral ankle instability by measuring anterior talar translation and the talar tilt angle [32]. According to the diagnostic criteria proposed by Jung et al. [22] for assessing lateral subtalar instability, we measured the subtalar tilt angle and calcaneal medial translation. Furthermore, we considered lateral laxation or opening of the subtalar joint was more significant than anterior translation of the calcaneus relative to the talus, since the intrinsic ligaments of the subtalar joint appeared normal and the medial deltoid ligament restricted anteroposterior movement [33]. Finally, intraoperative arthroscopy was used to definitively diagnose the lateral instability of the ankle and subtalar joints.

Another important criterion we included was the positive findings of lateral subtalar instability under C-arm fluoroscopic subtalar stress views [22]. Before the formal surgery, we routinely performed subtalar stress tests under anesthesia using C-arm fluoroscopy. We considered continuous fluoroscopic imaging under anesthesia as a reliable method for diagnosing subtalar instability.

Studies have highlighted the CFL's role in subtalar joint stability. Li et al. [9] reported that sectioning the CFL increases subtalar inversion during dorsiflexion, while Weindel et al. [34] found it causes excessive joint motion, leading to instability. Kamada et al. [35] further demonstrated that CFL repair can restore subtalar stability and alleviate symptoms. These findings align with our results, emphasizing the necessity of CFL repair to address subtalar instability in CLAI patients.

In this study, we observed that ATFL repair alone improved ankle joint stability but failed to fully restore subtalar joint stability, as indicated by residual subtalar tilt angle and medial calcaneal translation. However, adding CFL repair significantly improved these radiological parameters, confirming the importance of addressing STI through additional CFL repair, further confirmed our hypothesis.

There are few reports on the treatment of CLAI combined with STI. Lui et al. [36] described a technique for arthroscopic anatomical reconstruction of the ATFL and CFL to treat STI combined with CLAI, which helps reconstruct the stability of the ankle and subtalar joints. Choisne et al. [37] conducted simulations by sectioning and subsequently repairing key ligament structures on specimens. which significantly reduced subtalar and ankle inversion as well as subtalar internal rotation compared to the unstable condition. However, these studies are limited to technical and anatomical findings without clinical outcomes. This study is one of the first to comprehensively evaluate clinical and radiographic outcomes of arthroscopic ATFL and CFL repair in CLAI patients with STI. Postoperatively, both groups showed significant improvement in functional outcomes, but the ATFL + CFL group consistently outperformed the ATFL group in terms of pain relief and joint stability.

There were several limitations in this study. First, the preoperative diagnosis of STI remains challenging due to its reliance on stress radiographs, MRI, and intraoperative findings, which require expertise and may not be universally available. Second, the retrospective design and relatively small sample size limit the generalizability of the findings. Future studies with larger cohorts and prospective designs are needed to validate these results. Third, the follow-up period was brief, potentially affecting the long-term validity of the results. Finally, the study did not include cases involving other critical ligaments of the subtalar joint, such as the ITCL and CL. If these ligaments are injured, repairing the CFL alone may be insufficient to restore subtalar joint stability [38]. Further comprehensive research is required to address these limitations and enhance our understanding of effective treatments for instability of the ankle and subtalar joints.

Conclusion

The combined arthroscopic repair of the ATFL and CFL provides superior clinical and radiographic outcomes compared to isolated ATFL repair in managing CLAI with STI. This approach effectively restores stability in both the ankle and subtalar joints, improves functional recovery, and reduces pain. CFL repair should be considered in surgical planning to optimize outcomes and minimize the risk of recurrent instability.

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Author contributions
MWW, JZG and LW contributed equally to this work and should be considered co-first authors. ZY collected and analysed the data. KWQ performed and analyzed the experiments. WY conceived and coordinated the study, designed. QJZ conceived and supervised the work, and wrote the paper. All authors reviewed the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of the Second Affiliated Hospital of Soochow University (JD-HG-2024-082), and all patients provided written informed consent.

Consent for publication
Informed consent was obtained from all the patients in this study for the article to be published.

Competing interests
The authors declare no competing interests.

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