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Augmentation with the inferior extensor retinaculum may facilitate earlier recovery in all-inside arthroscopic management of chronic lateral ankle instability

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Abstract

Background To compare the clinical outcomes of inferior extensor retinaculum (IER) augmentation following repair of the anterior talofibular ligament (ATFL) with isolated ATFL repair in patients with an arthroscopically confirmed grade 3 lesion of the ATFL.

Methods We conducted a retrospective study of consecutive chronic lateral ankle instability (CLAI) patients who underwent arthroscopic ATFL repair between March 2018 and August 2022. The average age of the patients was 31.5 ± 7.4 years (range, 16–50 years). All patients underwent all-inside arthroscopic repair, and were divided into two groups based on the ligament repair method: the Broström-Gould group (*n* = 64) and the Broström group (*n* = 67). At 3, 6, 12 and 24 months after surgery, ankle inversion stress tests and anterior drawer tests were employed to assess the stability of the ankle joint. The American Orthopedic Foot and Ankle Society ankle hindfoot scale(AOFAS-AH) and Karlsson ankle function score (KAFS) were employed to assess ankle function; the Tegner score was employed to assess the patient's level of exercise; the Foot and Ankle Outcome Score [FAOS, including score of symptoms-diseases, pain, function-daily living score, function in sports and recreational activities, and quality of life] was used to assess the patient's daily activity ability.

Results The Tegner score, FAOS-function-daily living score, and FAOS-function in sports and recreational activities in the Broström-Gould group consistently outperformed the Broström group at 3 months and 6 months post-surgery, with the differences being statistically significant (all $P < 0.05$). However, although the differences are statistically significant, the clinical relevance of this statistical significance remains uncertain. At 12 and 24 months, there were no statistically significant differences between the two groups.

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Conclusions For CLAI patients with arthroscopic grade 3 lesion of the ATFL, both the all-inside arthroscopic Broström-Gould procedure and the Broström procedure provide stability and enhance ankle joint function, resulting in similar functional outcomes at a 2-year follow-up. IER augmentation following ATFL repair may facilitate earlier recovery exercises compared to isolated all-inside ATFL repair.

Keywords Chronic lateral ankle instability, Anterior talofibular ligament, Inferior extensor retinaculum, Arthroscopy

Background

Chronic lateral ankle instability (CLAI) is usually caused by elongation or rupture of the anterior talofibular ligament (ATFL) [1, 2], which connects the distal fibula to the talus, providing constraints on the sagittal translation and axial rotation of the talus, and also limiting excessive plantarflexion and inversion of the talocrural joint [3]. Hence, rupture or elongation of the ATFL not only leads to an increase in ankle inversion angle, but also increases its lateral plane movement (internal rotation) by 8–10% [4]. Especially under weight-bearing conditions, ankles with ATFL defects exhibit significant increases in forward translation and internal rotation [5]. In patients with CLAI, conservative management is usually the first choice. If non-operative measures are ineffective for 3 to 6 months, surgery can be indicated [6]. Direct ligament repair is commonly used, with the most common anatomical repair techniques including the classical Broström procedure, Gould modification, and Karlsson modification. All these techniques use the natural ligament residues with or without local tissue reinforcement [7, 8]. The Broström procedure for direct repair of ATFL and the Broström-Gould procedure for augmentation using the inferior extensor retinaculum (IER) are the gold standards for the treatment of CLAI [3, 6, 9, 10]. A comprehensive review comparing of non-anatomical repair versus anatomical repair over a period of at least 10 years indicates that anatomical repair yields better functional outcomes, while non-anatomical procedures are associated with a loss of range of motion and secondary arthritis [11].

An arthroscopic grade 3 ATFL lesion is characterized by a thinning of the ATFL ligament, which exhibits no mechanical resistance when palpated with an arthroscopy probe [12]. While some authors advocate for a direct repair of the ATFL, others believe that the quality of the ATFL is insufficient to restore ankle stability on its own and prefer a repair combined with IER augmentation. However, there is currently no consensus regarding the preferred surgical approach for patients with an arthroscopic grade 3 ATFL lesion. The purpose of this study was to clarify the necessity and clinical relevance of IER in the management of CLAI. We retrospectively analyzed and compared the clinical efficacy of all-inside arthroscopic Broström-Gould and Broström procedures. It was hypothesized that all-inside arthroscopic IER augmentation will yield superior outcomes compared to arthroscopic isolated ATFL repair for arthroscopic grade 3 ATFL lesion patients.

Methods

Patients

The project was approved by our institutional review board. We conducted a retrospective study of CLAI patients who were operated by a single fellowship trained surgeon at our hospital between March 2018 and August 2022.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) patients with CLAI who had failed conservative treatment for 1 year or more; (2) preoperative ankle magnetic resonance imaging indicating an elongated or redundant ATFL; (3) arthroscopy-confirmed ATFL tears on the fibular side of ATFL (thin ATFL ligament showing no mechanical resistance upon palpation using an arthroscopy probe [12, 13]; (4) cartilage injury in the talus is less than 150 mm^2 [14].

The exclusion criteria were as follows: (1) patients with combined instability of the subtalar joint; (2) patients with combined foot and ankle deformities, abnormal hindfoot alignment, fractures, joint stiffness, and injuries to other ligaments; (3) patients with combined central and peripheral neuromuscular atrophy or generalized ligament laxity; (4) individuals who had previously undergone ATFL repair; (5) ankle osteoarthritis, or osteochondral injury requiring bone and cartilage transplantation or more than 150mm^2; (6) follow up time less than 24 months or incomplete clinical data.

A total of 131 patients with CLAI who met our inclusion and exclusion criteria were treated at Xuzhou Central Hospital during the specified time period. The cohort comprised 65 males and 66 females, aged between 16 and 50 years, all of whom had experienced ankle sprains (Fig. 1).

Following discussions with the operating surgeon regarding the expected procedure duration, costs, and anticipated outcomes, patients were provided the choice between two surgical options: (a) all-inside arthroscopic Broström repair or (b) all-inside arthroscopic Broström repair with IER augmentation. Patients who were undecided had their procedure allocation determined by tossing a coin.

All patients underwent all-inside arthroscopic ligament repair surgery, and were divided into the Broström-Gould

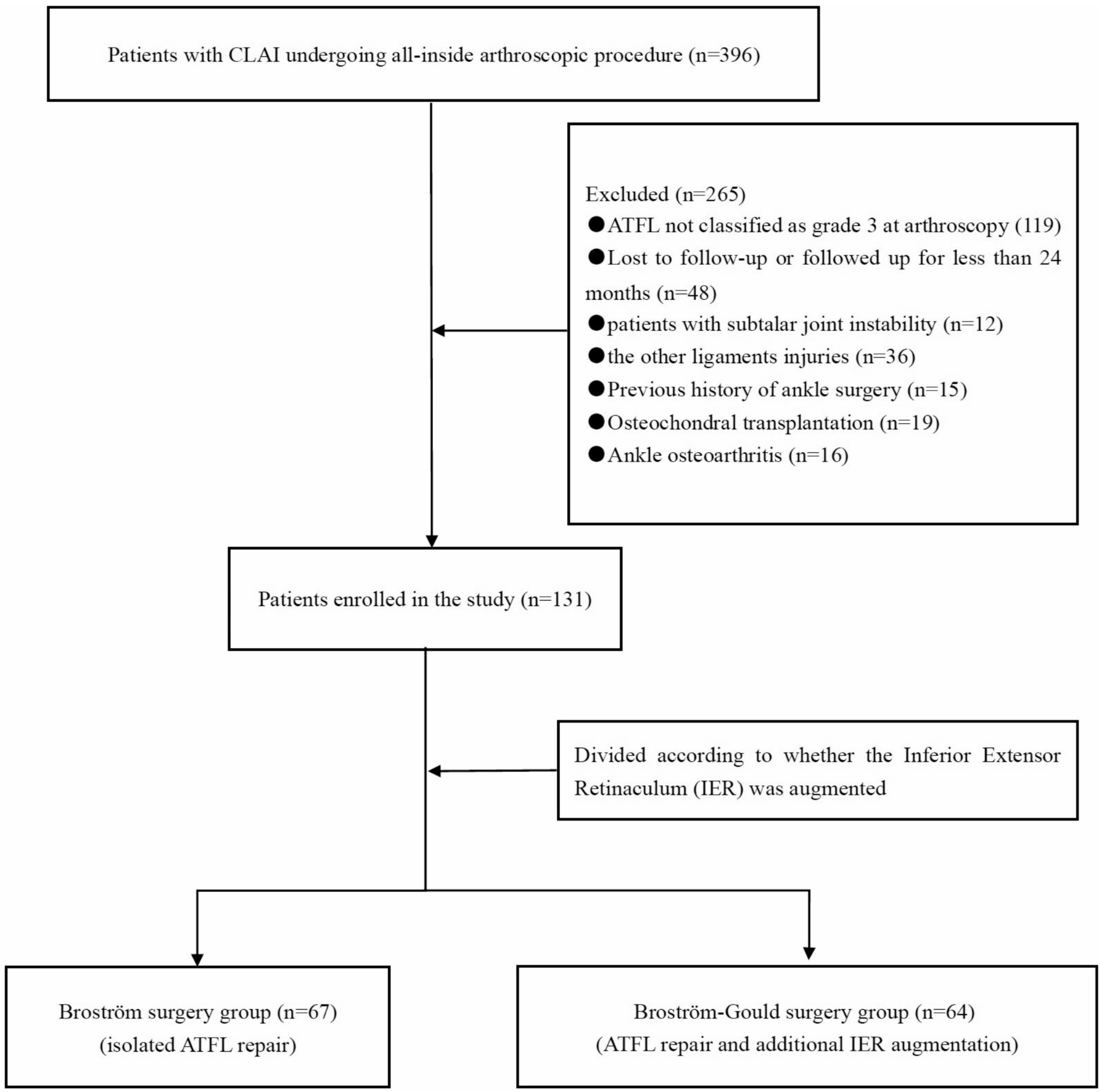

Fig. 1 Study flow diagram of the study

group ($n = 64$) and the Broström group ($n = 67$) according to the method of ligament repair. Data on age, sex, body mass index, and symptom duration were collected. No significant differences were found between the groups (Table 1).

Surgical technique

Patients were operated under spinal anesthesia, and all procedures were performed by a single fellowship trained surgeon. With the patient supine, a soft cushion approximately 7 cm high was placed under the affected hip. The standard anterolateral and anteromedial arthroscopic portals were initially established to evaluate and address the intra-articular pathology of the affected ankle. Microfracture was performed in patients with osteochondral lesion of the talus. An accessory anterolateral portal, located anterior to the fibular apex, was then established to provide better access to the lateral compartment of the ankle and the ATFL. A probe was introduced through this accessory anterolateral portal to assess the quality of the ATFL (Fig. 2). A motorized burr was used to refresh the footprint region of the ATFL on the anterior aspect of the distal fibula. A single loaded suture anchor (Healix Transtend 2.9 mm, Depuy Synthes) was

Table 1 Characteristics of the two groups[a]

	Broström group (*n* = 67)	**Broström-Gould group (*n* = 64)**	***p**-Value**
Age, year	32.0 ± 7.6	30.9 ± 7.3	0.390‡
Sex			0.664†
Male	32(47.8%)	33(51.6%)	
Female	35(52.2%)	31(48.4%)	
BMI, Kg/m^2	24.6 ± 1.7	25.0 ± 2.1	0.172‡
Symptom duration (months)	17.1 ± 2.5	17.9 ± 4.0	0.153‡

Abbreviations: BMI, body mass index

[a]Data are presented as mean ± SD or No. (%)

*A value $p < 0.05$ was set as statistically significant

†Pearson χ^2 test

‡t test

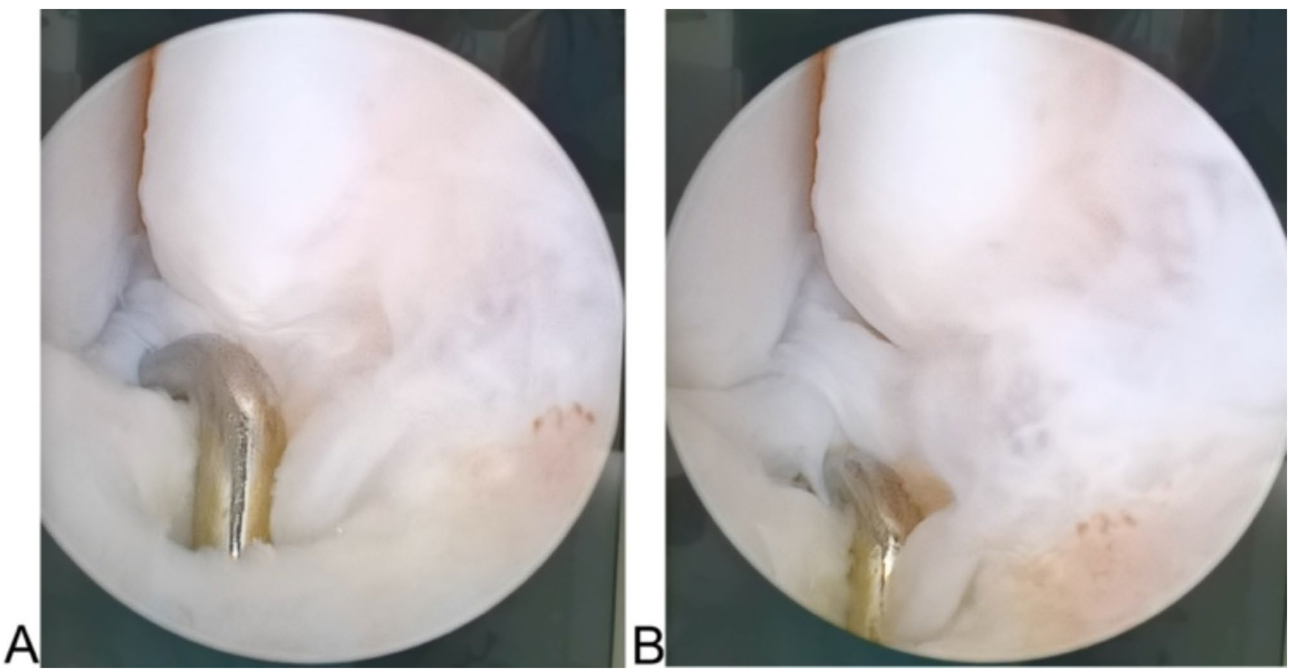

Fig. 2 Arthroscopic grade 3 lesion of the ATFL. **A** Arthroscopy-confirmed ATFL tears on the fibular side of ATFL; **B** Thin ATFL ligament showing no mechanical resistance upon palpation using an arthroscopy probe

inserted into the ATFL footprint region of the fibula via the accessory anterolateral portal. The ATFL remnant was sutured using a lasso-loop configuration (Fig. 3A). In the Broström-Gould group, an additional single loaded suture anchor (Healix Transtend 2.9 mm, Depuy Synthes) was inserted into the anterior aspect of the fibula, approximately 1 cm proximal to the first suture anchor. The IER was then sutured using the two limbs of the suture anchor, with the ankle positioned in slight dorsiflexion and valgus (Fig. 3B)

Postoperative rehabilitation

On the second day after surgery, patients were allowed to walk without weight-bearing and to perform functional exercises for the hip, knee, and toe joints of the affected limb, as well as isometric exercises for the lower limb muscles. Skin sutures were removed 2 weeks post-surgery, and the brace was maintained for 4 weeks after surgery. At the 4-week mark, patients were permitted to wear ankle-walking boots for weight-bearing and to perform functional exercises of the ankle. The range of motion of the ankle joint was limited to 10 degrees of dorsiflexion and 20 degrees of plantarflexion, avoiding inversion and eversion. Muscle strength training around the ankle was initiated. After 6 weeks, the range of motion, varus, and flexion of the ankle gradually increased. By 8 weeks post-surgery, the ankle-walking boot was removed, full weight-bearing was allowed, and patients were advised to gradually resume physical activity

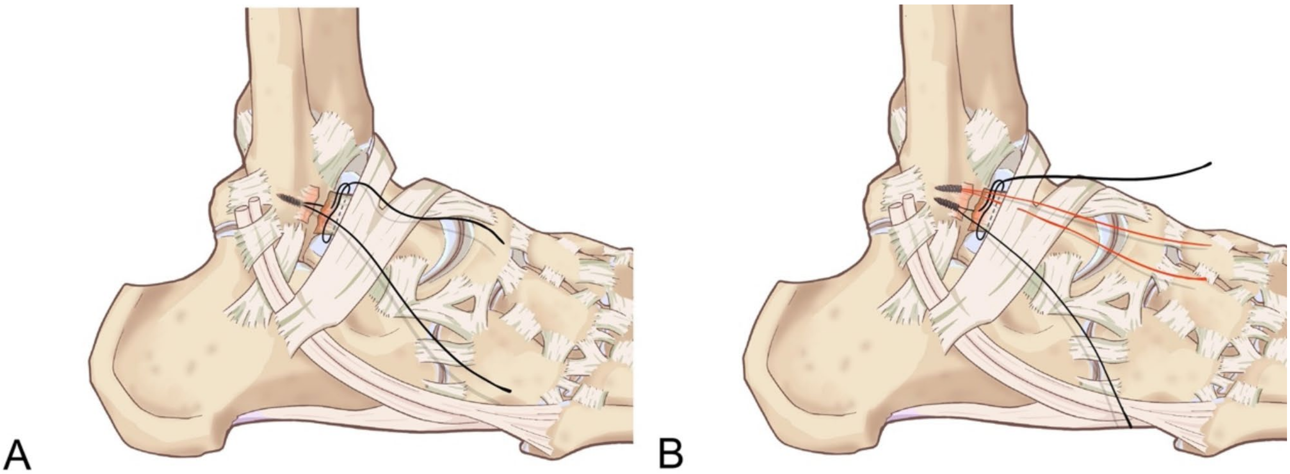

Fig. 3 Surgical diagrams of the two all-inside arthroscopic procedures. **A** The ATFL repair procedure; **B** The ATFL repair and additional IER augmentation procedure

Outcomes assessment

Follow-up visits were conducted at 2 weeks (after removing the brace), and at 3, 6, 12 and 24 months post-surgery. During these visits, the stability of the ankle joint was assessed using the varus stress test and the anterior drawer test, and the patient's gait was observed. Additionally, at 3, 6, 12 and 24 months post-surgery, the American Orthopedic Foot and Ankle Society (AOFAS) score and the Karlsson Ankle Functional Score (KAFS) were used to evaluate ankle function [15–17]. The Tegner score was used to assess the patient's level of physical activity [18], and the Foot and Ankle Outcome Score (FAOS) was administered to evaluate symptoms, functional limitations, and activity ability across five subitems: symptoms-diseases, pain, function-daily living score, function in sports and recreational activities, and quality of life [19–21]. Higher scores indicated better outcomes

Statistical analysis

Data are presented as mean ± standard deviation (SD). Statistical comparisons between the two groups were performed using the Student's t-test for normally distributed data and the Mann-Whitney U test for non-normally distributed continuous data. The chi-square test was used for categorical data. Repeated measures analysis of variance (ANOVA) was conducted for the comparison of repeated measurement data. When the interaction effect was not significant, the main effect was analyzed; when the interaction effect was significant, the simple effect was analyzed. Post hoc multiple comparisons were performed using the LSD-*t* test. The Wilcoxon signed-rank test was used for comparisons between preoperative and postoperative parameters regarding clinical and functional outcomes. Group sample sizes of 67 and 64 achieve less than 20.00% power (AOFAS and KAFS) to reject the null hypothesis of equal means, with a significance level (alpha) of 0.050 using a two-sided two-sample unequal-variance t-test. Statistical analysis was performed using SPSS software (Version 26.0; IBM). The α value was set at 0.05, and a P value < 0.05 was considered statistically significant

Results

Clinical outcomes

At arthroscopy, ATFL elongation and loss of tension were observed in all patients. Seven patients had small fractures on the fibular side, which were thoroughly debrided. Microfracture of the talus was performed in 15 patients in the Broström group and 13 patients in the Broström-Gould group, with no significant difference between the two groups ($p = 0.772$). The entry portal incisions healed without complications. All patients in both groups were followed up at 3 months, 6 months, 12 months and 24 months post-surgery. During the follow-up period, persistent swelling was observed in one patient in each group. The gait returned to normal, without any mechanical or functional instability. No patient required revision surgery

The results of the repeated measures analysis of variance revealed significant group-by-time interaction effects for the Tegner score ($F = 9.170$, $P < 0.001$), the FAOS function-daily living score ($F = 3.215$, $P = 0.015$), and the FAOS function in sports and recreational activities score ($F = 6.141$, $P < 0.001$). These findings suggest that the patients' motor function exhibited different trends at various time points depending on the type of surgical treatment received. The time main effects for AOFAS-AH, Tegner, KAFS, and FAOS scores were significant, with statistically significant differences in patient scores at different time points (all $P < 0.05$). Postoperative scores were significantly higher than preoperative scores.

The group effects for AOFAS-AH, Tegner, KAFS, and FAOS scores were not significant. (Table 2)

Simple effect analysis of the Tegner score, FAOS-function-daily living score, and FAOS- function in sports and recreational activities scores revealed significant differences at 3 and 6 months, but no significant differences at 12 and 24 months. Multiple comparisons (LSD-t) revealed that the Tegner score, FAOS-function-daily living score and FAOS-function in sports and recreational activities score in the Broström-Gould group consistently outperformed the Broström group at 3 and 6 months post-surgery, with the differences being statistically significant (all $P<0.05$). (Figures 4 and 5)

Complications

There were no complications in terms of wound infection, nerve injury, vascular injury, and tendon injury. At final follow-up, patients had no mechanical or symptomatic instability of the ankle. Good clinical outcomes in all the patients were observed without instance of ankle pain, joint stiffness, and arthritis to the final follow-up

Discussion

The main finding of the present study was that both the all-inside arthroscopic Broström-Gould procedure and the Broström procedure effectively stabilize and improve the function of the ankle joint in patients with arthroscopic grade 3 ATFL lesion. Additional IER augmentation following ATFL repair results in significantly improved motor function scores and faster initial recovery during the first six months post-surgery. However, the outcomes of both procedures become comparable two years after the operation

The Broström procedure was proposed in 1966, and the Broström modified procedure was described by Gould et al. in 1980. Since then, the Broström procedure and Broström-Gould procedure have become the gold standard for the surgical management of CLAI [3, 8, 10, 22]. Nevertheless, there has been controversy about whether it is necessary to carry out additional IER augmentation. In most comprehensive studies on ATFL grade 3 lesion, the primary treatments for CLAI include additional IER augmentation surgery, ATFL ligament reconstruction, or direct ligament repair (Brostrom surgery) [23, 24]. However, there is still no consensus on the optimal surgical approach. To our knowledge, this study is the first to focus exclusively on ATFL grade 3 lesion. In the present study, we compared the clinical outcomes of all-inside arthroscopic Broström-Gould procedure and Broström procedure in the treatment of CLAI patients with ATFL grade 3 lesion. We found that augmented the IER for the aforementioned patients enabled them to resume exercise earlier, and they achieved higher scores in the FAOS-function in sports and recreational activities score, FAOS-function-daily living score and Tegner scores at both 3 months and 6 months. However, these results, though statistically different, are of dubious clinical relevance, and the outcome of the two techniques became fully comparable at the 2-year follow-up

In a cadaveric study of 200 specimens, the Broström-Gould procedure provided additional support to the hindfoot, reducing varus and axial rotation, and the degree of varus was beyond the scope of intact ligaments. There was no significant difference in the pattern of pressure center shift between Broström-Gould procedure and intact ligament condition [25]. In another cadaveric study, the Broström-Gould repair improved the ability of the ankle to resist varus and rotation [26]. The all-inside arthroscopic Broström-Gould augmentation was therefore considered a reasonable surgical alternative for chronic ankle instability [27]. Based on the existing biomechanical evidence, arthroscopic Broström-Gould surgery can enhance the function of the ankle in a cadaver model

In clinical studies, both the arthroscopic Broström-Gould procedure and the arthroscopic Broström procedure yield short and long-term comparable clinical outcomes compared to the open surgical approaches [28–32]. Hou et al. [28] compared it to the open modified Broström procedure: the arthroscopic group had a shorter recovery time and higher recovery rate after 6 months of surgery with better clinical scores, posture control, and muscle strength. The Broström-Gould arthroscopic procedure is comparable to the traditional open Broström-Gould surgery and has the advantage of earlier weight-bearing [33]. Both all-inside arthroscopic Broström-Gould surgery and traditional open Broström-Gould surgery have comparable imaging and clinical outcomes in high demand CLAI patients. The median Tegner activity level before injury was 7, which remained unchanged at final follow-up in both groups [34]. In a follow-up study of 38 patients for an average of 9.8 years, nearly all patients achieved excellent or good postoperative AOFAS scores (94.7%). They suggest that the arthroscopic Broström-Gould assisted technique may serve as a viable alternative to the standard Broström-Gould surgery for the anatomical repair of chronic lateral ankle instability and the management of intra-articular pathologies [32]

Regarding the augmentation using the IER, some studies indicated that the oblique upper lateral zone is a thin tissue band, and it may not significantly enhance ankle stability [35]. A two-year follow-up study pointed that additional IER augmentation after arthroscopic ATFL repair does not result in better clinical efficacy [13]. In the medium and long-term follow-up of patients with CLAI after surgery, both Broström-Gould and Broström procedures had good clinical effects, with no significant

Table 2 Comparison of the functional outcomes between Broström-Gould ($n=64$) and Broström group ($n=67$)[a]

	Broström group ($n=67$)	**Broström-Gould group ($n=64$)**	**Time effect (p*-value)**	**Group effect (p*-value)**	**Interaction effect (p*-value)**
AOFAS-AH			<0.001†	0.622†	0.618†
Pre-operation	63.7 ± 5.0	63.2 ± 6.0			
3 months	83.9 ± 1.7	84.1 ± 2.1			
6 months	88.2 ± 2.6	88.7 ± 2.3			
12 months	92.0 ± 2.6	92.7 ± 3.0			
24 months	94.8 ± 1.8	94.7 ± 1.8			
Tegner Score			<0.001†	0.057†	<0.001†
Pre-operation	1.8 ± 0.6	1.7 ± 0.5			
3 months	3.3 ± 0.6	3.6 ± 0.6			
6 months	4.0 ± 0.7	4.5 ± 0.7			
12 months	5.4 ± 0.9	5.5 ± 0.9			
24 months	6.4 ± 0.7	6.5 ± 0.7			
KAFS Score			<0.001†	0.473†	0.574†
Pre-operation	51.0 ± 5.0	50.6 ± 4.6			
3 months	83.1 ± 3.5	83.7 ± 4.4			
6 months	89.6 ± 3.6	90.5 ± 3.6			
12 months	92.2 ± 3.6	92.2 ± 3.6			
24 months	94.4 ± 2.8	94.8 ± 2.7			
FAOS-symptoms, diseases			<0.001†	0.075†	0.441†
Pre-operation	59.1 ± 5.9	60.5 ± 6.0			
3 months	82.9 ± 2.8	83.4 ± 2.5			
6 months	88.7 ± 3.3	89.1 ± 2.8			
12 months	92.1 ± 3.4	92.9 ± 3.1			
24 months	95.6 ± 2.4	95.7 ± 2.1			
FAOS-pain			<0.001†	0.380†	0.086†
Pre-operation	59.3 ± 6.3	60.5 ± 5.8			
3 months	84.4 ± 3.7	83.7 ± 2.6			
6 months	89.1 ± 4.0	89.6 ± 3.3			
12 months	92.3 ± 2.9	92.9 ± 2.3			
24 months	94.1 ± 1.8	93.9 ± 2.2			
FAOS-function-daily living score			<0.001†	0.087†	0.015†
Pre-operation	62.0 ± 5.4	61.7 ± 4.1			
3 months	87.9 ± 1.5	89.2 ± 2.1			
6 months	89.9 ± 2.3	91.1 ± 2.0			
12 months	92.6 ± 2.4	93.1 ± 2.5			
24 months	94.6 ± 2.6	94.4 ± 2.6			
FAOS-function in sports and recreational activities			<0.001†	0.080†	<0.001†
Pre-operation	50.6 ± 4.6	49.7 ± 5.2			
3 months	80.1 ± 3.6	82.5 ± 4.2			
6 months	85.3 ± 3.8	87.5 ± 4.1			
12 months	90.7 ± 3.8	91.3 ± 3.8			
24 months	94.3 ± 1.8	93.8 ± 2.5			
FAOS-quality of life			<0.001†	0.247†	0.811†
Pre-operation	35.4 ± 6.3	36.5 ± 6.9			
3 months	80.8 ± 5.6	81.1 ± 6.6			
6 months	87.5 ± 4.9	88.1 ± 5.3			

Table 2 (continued)

	Broström group (*n* = 67)	Broström-Gould group (*n* = 64)	Time effect (*p**-value)	Group effect (*p**-value)	Interaction effect (*p**-value)
12 months	90.6 ± 4.1	91.6 ± 5.1			
24 months	93.6 ± 3.8	93.8 ± 3.3			

Abbreviations: AOFAS-AH, American Orthopedic Foot & Ankle Society ankle hindfoot scale; KAFS, karlsson ankle functional score; FAOS, Foot and Ankle Outcome Score

[a]Data are presented as mean ± SD

*A value $p < 0.05$ was set as statistically significant

†A repeated measures analysis of variance (ANOVA)

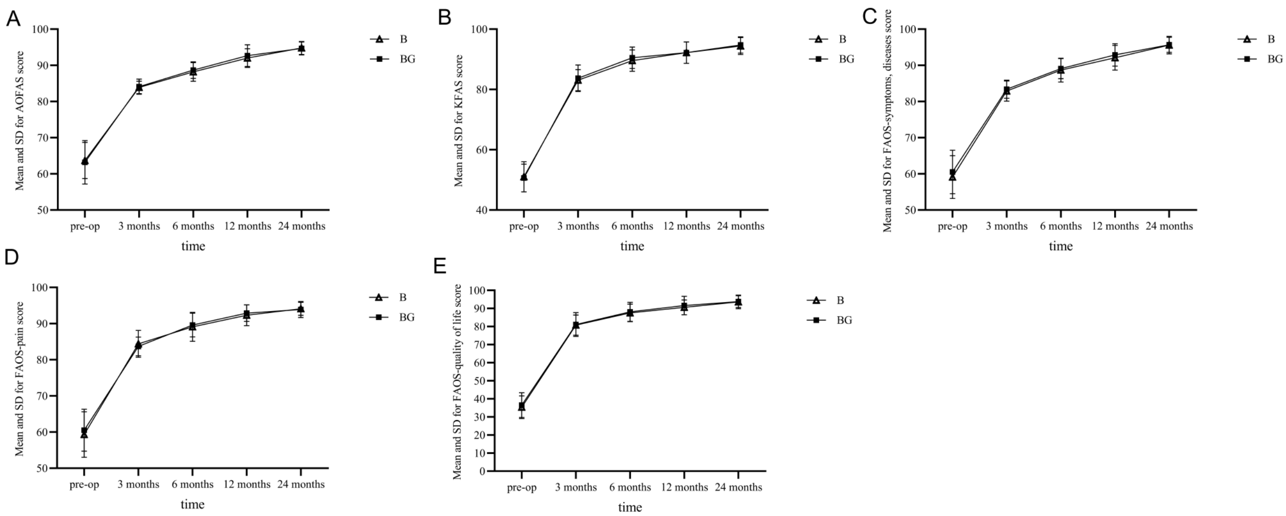

Fig. 4 The patient's ankle function was reported using the AOFAS (**A**), KAFS(**B**), FAOS symptoms, diseases (**C**), FAOS pain (**D**), and FAOS quality of life (**E**) scores during the follow-up. The postoperative scores of both groups improved significantly, but there was no significant difference between the two groups during the follow-up. B, Broström group. BG, Broström-Gould group. pre-op, preoperative

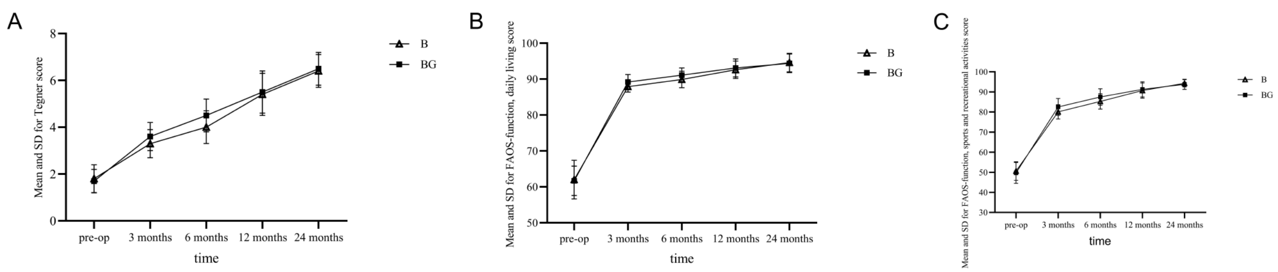

Fig. 5 The patient's ankle function was reported using the Tegner (**A**), FAOS-function-daily living score (**B**) and FAOS function in sports and recreational activities scores (**C**) during the follow-up. The trend showed a statistically significant improvement at the early follow-up, but this improvement was not maintained at the final follow-up. B, Broström group. BG, Broström-Gould group. pre-op, preoperative

difference. Augmented repair with IER offers initial protection for the repaired ATFL and enhances joint rotation function [36–40]. The present study conducted careful follow-ups on patients at 3 months, 6 months, 12 months, and 24 months post-surgery, meticulously assessing the functional status of the ankle at each stage. Patients with a poor-quality ATFL ligament experience a higher failure rate post-surgery. Conversely, a better quality ligament was associated with better clinical outcomes, particularly in terms of a higher likelihood of returning to sports [41–43]. The poor quality of the remaining ATFL, replaced by scar tissue, may impede successful repair, and simple repair of the frail ligament may be insufficient to restore stability [42]. In these patients, surgeons should consider augmenting or reconstructing the ligament

In the present study, all patients presented a grade 3 ATFL lesion. Patients who underwent the Gould modification experienced higher early postoperative motor ability, similar to the study findings of Vega et al. [44], especially in patients with poor residual ligament-tissue quality. Differently from Vega et al. [44], we introduced a control group in whom an isolated ATFL repair has been performed. At the 24-month follow-up, the Tegner score, FAOS-function-daily living score, and FAOS-function in sports and recreational activities in the Broström-Gould group showed superior outcomes at both 3 and 6 months post-surgery compared to the Broström group. However, we caution that the early statistically significant advantage observed with IER augmentation may have limited clinical relevance, as the minimal clinically important difference for these measurements has not yet been established

A study compared arthroscopic ankle lateral ligament repair alone with ankle lateral ligament repair combined with IER reinforcement for treating chronic ankle instability, with no difference in clinical outcomes between the two groups, and the IER reinforcement actually increased the duration of the procedure [45]

Limitations

There are several limitations in this study: (1) Postoperative functional evaluation was based on subjective functional evaluation indicators for patients, lacking relatively objective indicators such as postoperative stress radiographs or secondary arthroscopic assessment. (2) The present study is a single-center single-surgeon retrospective analysis with a relatively limited patient sample. Prospective, possibly randomized, multicenter, and larger-scale studies are needed to confirm its efficacy. (3) Our data cannot definitively confirm the long-term durability of successful arthroscopic repair without IER enhancement. Further medium- and long-term follow-up studies are needed to provide confirmation. Finally, the present investigation was not planned as a health economic study. However, it is intuitive that IER is more technically demanding, requires longer operative time, and the use of two instead of one single anchor. All these issues contribute to higher direct and indirect costs of the IER augmentation procedure

Conclusions

In summary, both the all-inside arthroscopic Broström-Gould procedure and the Broström procedure can achieve stability and improve the function of the ankle joint in patients with arthroscopic ATFL grade 3 lesion. The additional IER augmentation after ATFL repair yields statistically better scores in motor function and facilitate earlier recovery; however, the clinical relevance of this statistical significance remains uncertain

Abbreviations

IER	Inferior extensor retinaculum
ATFL	Anterior talofibular ligament
AOFAS-AH	The American orthopedic foot and ankle society ankle hindfoot scale
KAFS	Karlsson ankle function score
FAOS	The foot and ankle outcome score
CLAI	Chronic lateral ankle instability
BMI	Body mass index

Author contributions

XL, CX and ZHZ collected and analysed the data, and helped in reviewing the literature. KF helped in the interpretation of the data. NM supervised the work, interpreted the data, and wrote the drafts and the final versions of the manuscript. FM helped to analyse and interpret the data. SMF conceived and supervised the work, interpreted the data, and wrote the drafts and the final versions of the manuscript. All authors reviewed the manuscript.

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Data availability

The data from which this study arose are available from the corresponding authors upon reasonable request.

Declarations

Ethics approval and consent to participate

The Ethics Committee of the Xuzhou Central Hospital approved all experimental procedures in conformity with the Declaration of Helsinki. Informed consent was obtained from all patients included in the study.

Consent for publication

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

Competing interests

Prof N Maffulli is the Editor in Chief of the Journal of Orthopaedic Surgery and Research.

Disclosures

None of the authors has any commercial associations or financial disclosures that might pose or create a conflict of interest with information presented in this article. Prof. Maffulli is the Editor in Chief of the Journal of Orthopaedic Surgery and Research.

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