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All-arthroscopic reconstruction of the anterior talofibular ligament is comparable to open reconstruction: a systematic review

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- The aim of this study was to determine whether all-arthroscopic repair would lead to improved clinical outcomes, lower complication rates, shorter postoperative immobilization and earlier return to activity compared to open Broström repair in the surgical treatment of chronic lateral ankle instability (CLAI).
- A systematic literature search was conducted using Pubmed and Embase to identify studies dealing with a comparison of outcomes between all-arthroscopic and open Broström repair for CLAI. The search algorithm was 'ankle instability' AND 'Brostrom' AND 'arthroscopic' AND 'open'. The study had to be written in English language, include a direct comparison of all-arthroscopic and open Broström repair to treat CLAI and have full text available. Exclusion criteria were former systematic reviews, biomechanical studies and case reports.
- Overall, eight studies met the inclusion criteria and were included in the analysis. Clinical outcomes did not differ substantially between patients treated with either arthroscopic or open Broström repair. Studies that reported on return to activity and sports following surgery suggested that patients that had all-arthroscopic Broström repair returned at a quicker rate. Overall complication rate tended to be lower after arthroscopic Broström repair.
- Similar to open repair, all-arthroscopic ligament repair for CLAI is a safe treatment option that yields excellent clinical outcomes.
- Level of Evidence: Level III evidence (systematic review of level I, II and III studies).

Keywords

- chronic lateral ankle instability
- Broström
- ankle arthroscopy

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Introduction

Lateral ankle sprains are among the most common injuries in sports (1, 2, 3). The anterior talofibular ligament (ATFL) is the most frequently injured ligament, followed by the calcaneofibular ligament (CFL) (4, 5, 6). Only in rare cases and following severe traumata, the entire lateral ligament complex ruptures (7, 8). In most cases of lateral ligament injury, conservative treatment yields good results, and approximately 80–90% of patients regain ankle stability by immobilization in a brace (9, 10, 11). However, about 10 to 20% develop chronic lateral ankle instability (CLAI) and consequently require surgical ligament repair (12, 13). The Broström technique as well as its modifications is considered the gold standard for treating CLAI. The Broström repair includes a direct suture of the torn ends of the ATFL and CFL (14, 15, 16). The well-known Broström–Gould modification by Gould *et al.* makes use of the inferior extensor retinaculum to support the ATFL remnants and provide a more stable repair (13). Another modification introduced by Karlsson *et al.* in 1988 suggested reattaching the ATFL and CFL through drill holes, as they were often not completely ruptured, but elongated and scarred (17).

In recent years, interest in less invasive methods to perform lateral ligament repair has increased, including arthroscopic techniques (18, 19, 20). Arthroscopic-assisted repair combines arthroscopic repair with a percutaneous or mini-open approach (19, 21, 22, 23, 24). All-arthroscopic repair involves an anatomical repair of the lateral ligaments in a fully arthroscopic procedure (25, 26, 27, 28). Both methods present the advantage of a minimally invasive approach and the chance to address other injury-related pathologies such as synovitis, intra- and periarticular soft-tissue adhesions and removal of loose joint bodies (29). However, arthroscopy is associated with a high complication rate, as sensitive nerve and vessel structures pass within a short distance of the common arthroscopic portals (30, 31). Anatomical and clinical studies have shown that the intermediate dorsal cutaneous branch of the superficial peroneal nerve is the most frequently injured nerve during ankle arthroscopy (32, 33, 34).

Up until now, there is still no evidence whether open or all-arthroscopic lateral ligament repair should be considered as the gold standard.

The aim of this study was to determine whether all-arthroscopic repair would lead to improved clinical outcomes, lower complication rates, shorter postoperative immobilization and earlier return to activity compared to open Broström repair in the surgical treatment of CLAI. The authors hypothesized that all-arthroscopic repair would result in improved outcome and earlier return to activity due to the less invasive approach.

Methods

A systematic literature search according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines was conducted using Pubmed and Embase to identify studies dealing with a comparison of outcomes between all-arthroscopic and open Broström repair for CLAI (35). The final search date was February 20, 2021. Search was not restricted by language or year of publication. The search algorithm was 'ankle instability' AND 'Brostrom' AND 'arthroscopic' AND 'open'. Articles with levels I, II, III or IV evidence were regarded eligible. As especially all-arthroscopic lateral ligament repair is still a relatively novel approach and literature on this topic, especially direct comparison to open Broström repair, is still rare, non-randomized cohort studies as well as randomized trials were included. To quantify the risk of selection bias and potential confounders associated with non-randomized trials, a methodological index called MINORS was calculated for all those trials and summarized in Table 1, with a global ideal score of 24 for comparative studies (36). Articles in print journals as well as electronically published studies and conference records were considered eligible for analysis. Manual cross-checking of all references in the accepted papers and other recent reviews was performed in order to supplement the electronic searches and to identify any additional records in the scope of the study topic. Disagreement concerning study choice was resolved by discussion between the first and senior author until agreement was achieved. To satisfy inclusion criteria, the study had to (i) include a direct comparison of all-arthroscopic and open Broström repair to treat CLAI. Moreover, paper (ii) had to be written

Table 1 Overview of included studies.

Reference	Study design	Level of evidence	Minors, *n*	Patients, *n*	Age (years)*	Gender ratio (M/F)	Follow-up (months)*
Zhou *et al.* (37)	RCS	III	18				
AI				31	33.4 ± 6.4	20/11	29.7 ± 3.4
O				36	31.4 ± 7.8	23/13	33.1 ± 6.8
Woo *et al.* (38)	RCS	III	19				
AI				26	33.4 ± 10.6	16/10	12
O				26	31.5 ± 10.3	16/10	12
Zeng *et al.* (39)	RCS	III	18				NA
AI				17	30.9 ± 6.0	15/2	
O				10	27.7 ± 9.7	7/3	
Xu *et al.* (40)	RCS	III	22				
AI				32	33.7 ± 7.0	24/8	36.5 ± 12.7
O				35	35.8 ± 8.5	25/10	39.1 ± 9.2
Rigby *et al.* (41)	RCS	III	18				
AI				30	47.9 (14–83)	9/21	15.6 (8.4–20.4)
O				32	37.7 (9–72)	14/18	44.4 (15.6–63.6)
Li *et al.* (42)	RCS	III	20				
AI				23	30.3 ± 10.1	18/5	39.7 ± 10.3
O				37	28.7 ± 8.7	29/8	35.5 ± 9.9
Yeo *et al.* (43)	RCT	I					
AI				25	35.2 (19–54)	7/18	12
O				23	34.3 (17–52)	12/11	12
Matsui *et al.* (44)	RCS	III	17				
AI				19	28 (8–59)	12/7	12
O				18	24 (13–56)	8/10	12

*Data are presented as mean ± S.D. or as mean (range).
AA, arthroscopically assisted Broström; AI, all-inside arthroscopic Broström; F, female; M, male; NA, not applicable; O, open Broström; RCS, retrospective cohort study; RCT, randomized controlled trial.

in English language and (iii) full text had to be provided. Exclusion criteria were (i) former systematic reviews, (ii) cadaveric or biomechanical studies and (iii) case reports.

Literature search and consequently study selection were performed by the first author of the study. Articles considered eligible were then reviewed by both the first and senior authors.

Statistical analysis

Statistical analysis was performed using Review Manager Version 5.4 software (The Cochrane Collaboration). To quantify heterogeneity between studies, the I^2 statistic was conducted and forest plots were used for graphical representation (22). Low heterogeneity was indicated by an I^2 value of <25%, while high heterogeneity was determined by an I^2 value of >75%. If the I^2 value was >50%, a random-effects model was used; otherwise, a fixed-effects model was applied. A descriptive summary of demographic data of the respective patient cohorts was depicted as frequency (absolute numbers, percentage) for qualitative variables and mean, S.D. and range for quantitative variables.

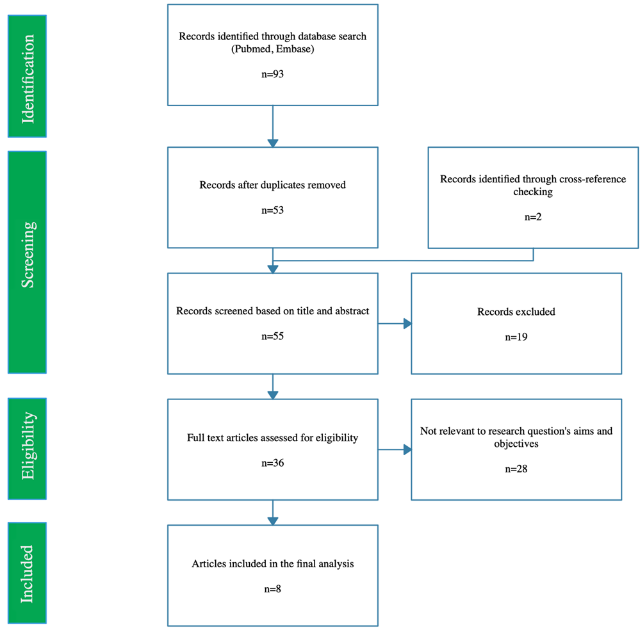

Figure 1
PRISMA flow diagram of the identification of relevant studies.

Results

The electronic database search using the above-mentioned keywords revealed 93 studies. After the removal of duplicates, 53 articles were left to be considered. Through manual cross-referencing, two additional records were identified. After applying the predefined inclusion and exclusion criteria and screening by title and abstract, 36 articles were left potentially eligible. After review of the full-texts, 28 studies were excluded, as they were not in the scope of this review, leaving 8 papers eligible. Finally, eight studies were included in the analysis. The PRISMA flow diagram of the search algorithm is depicted in Fig. 1.

Full text articles of the included studies were either downloaded from the respective journal's website or inquired via the author's own online library.

Of the included studies, seven were retrospective cohort studies and one was a randomized controlled trial. A summary of the study characteristics is depicted in Table 1.

Table 2 summarizes the clinical outcomes measured by different scores including American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Score (AOFAS), visual analog scale (VAS) and the Karlsson Score.

Clinical outcome scores

Postoperative AOFAS scores were reported in seven studies (Zhou *et al.* (37), Woo *et al.* (38), Zeng *et al.* (39), Xu *et al.* (40), Rigby *et al.* (41), Li *et al.* (42), Yeo *et al.* (43)). VAS scores were reported in six studies (Zhou *et al.* (37), Woo *et al.* (38), Xu *et al.* (40), Rigby *et al.* (41), Yeo *et al.* (43), Matsui *et al.* (44)). The forest plots are depicted in Figs 2 and 3. The Karlsson score was presented in six studies (Zhou *et al.* (37), Zeng *et al.* (39), Xu *et al.*

Table 2 Evaluation of clinical outcomes. Data are presented mean ± S.D., mean (S.E.M.) or as mean (range).

Reference	AOFAS	VAS	Karlsson score
Zhou *et al.* (37)			
AI	91.71 ± 5.46	1.74 ± 1.24	87.52 ± 7.59
O	90.67 ± 5.59	1.58 ± 1.2	88.75 ± 5.56
Woo *et al.* (38)			
AI	94.2 ± 10.0	1.2 ± 2.7	
O	70.9 ± 33.1	2.1 ± 2.6	
Zeng *et al.* (39)			
AI	92.4 ± 5.9		89.2 ± 8.4
O	91.1 ± 6.2		90.5 ± 8.8
Xu *et al.* (40)			
AI	87.7 ± 7.6	1.8 ± 1.6	83.1 ± 8.2
O	86.9 ± 7.3	2.1 ± 1.7	81.7 ± 9.1
Rigby *et al.* (41)			
AI	95.33 (55–100)	1.5 (0–10)	91.8 (55–100)
O	93.53 (49–100)	1.2 (0–9.5)	93.41 (54–100)
Li *et al.* (42)			
AI	93.3 ± 8.9		90.3 ± 12.5
O	92.4 ± 8.6		89.4 ± 10.6
Yeo *et al.* (43)			
AI	90.3 (2.4)	1.7 (0.4)	76.2 (2.8)
O	89.2 (2.3)	2.0 (0.4)	73.5 (2.8)
Matsui *et al.* (44)	NA		
AI		1.24 (0–5.5)	
O		1.92 (0.4–6.2)	

AI, all-inside arthroscopic Broström; AA, arthroscopically assisted Broström; O, open Broström; TTA, talar tilt angle.

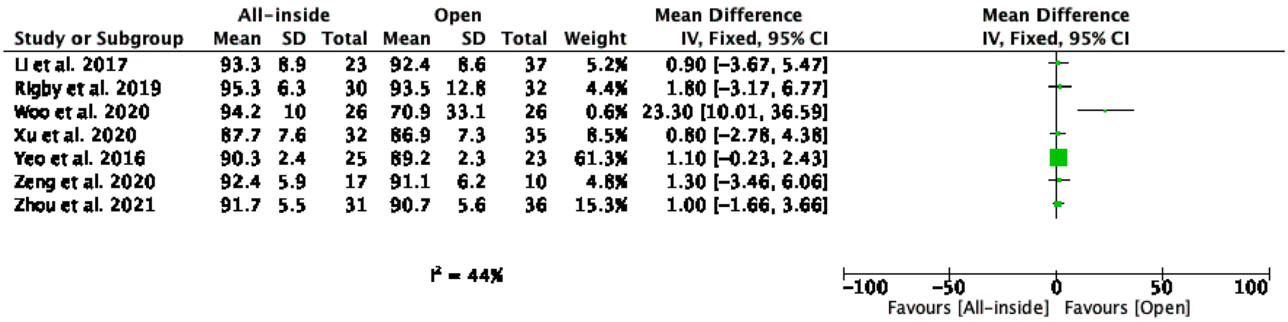

Figure 2
Results of aggregate analysis for the comparison of AOFAS scores between AI and O groups. IV, inverse variance.

(40), Rigby *et al.* (41), Li *et al.* (42), Yeo *et al.* (43)). The forest plot is depicted in Fig. 4. None of the three reported clinical outcome scores tended to be substantially in favor of either arthroscopic or open repair.

Postoperative treatment and return to activity

An overview of postoperative treatment protocols and return to sports is given in Table 3. Seven of the eight included studies applied the same postoperative protocols to both patient collectives, whether Broström repair was performed arthroscopically or open.

In the study by Rigby *et al.* (41), different postoperative rehabilitation protocols were applied. In their study, mean time to weightbearing amounted to 12 days (range, 9–16 days) in the arthroscopic group and was thus substantially shorter than in the open Broström group, where the mean time to weightbearing was 22 days (range, 20–26 days). However, eventually, 97% were able to return to full activity compared to before the lateral ligament injury happened, which was equal for both groups.

In the study by Matsui *et al.* (44), mean return to daily activity and mean return to sports were calculated. Return to daily activity was significantly shorter in the arthroscopic Broström group with a mean of 5.3 weeks (range, 3–12 weeks) compared to 7.1 weeks (range, 5–12 weeks) in the open group ($P < 0.05$). Moreover, return to sports was also faster in the arthroscopic Broström group with a mean of 16.5 weeks (range, 12–22 weeks) versus 17.1 weeks (range, 13–22 weeks) in the open group, although not statistically significant ($P = 0.07$).

In most studies, even partial weightbearing was prohibited for the first 2–6 weeks. However, in the study by Matsui *et al.* (44), weightbearing as tolerated was permitted immediately after surgery in both the arthroscopic and the open Broström group.

Complication rates

Complication rates, especially concerning wound healing, irritation of the peroneal nerve, knot pain and the need for revision surgery, were reported in all included trials. An overview is given in Table 4. The concomitant forest plots are depicted in Figs 5, 6, 7 and 8. Overall complication rate tended to be lower after arthroscopic Broström repair. Moreover, impaired wound healing tended to occur more often after open Broström repair. On the other hand, irritations of the peroneal nerve and knot pain tended to be more likely after arthroscopic Broström repair.

Discussion

One of the most important findings of this study was that clinical outcomes did not differ substantially between

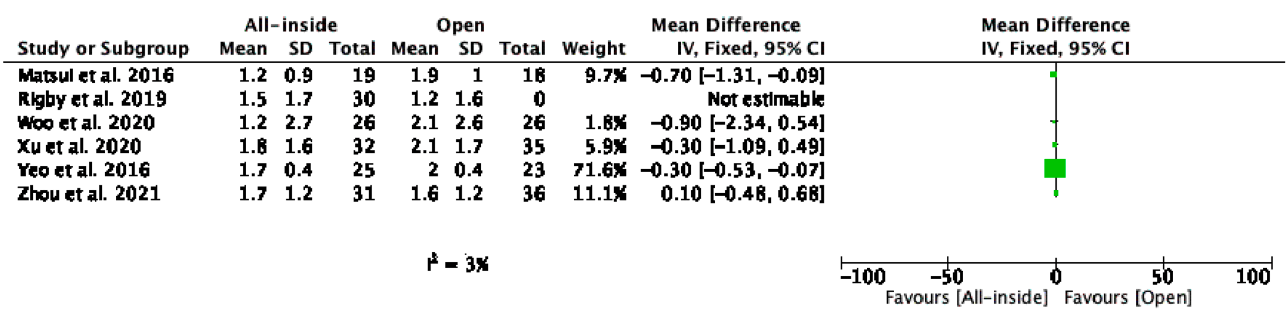

Figure 3
Results of aggregate analysis for the comparison of total VAS scores between AI and O groups. IV, inverse variance.

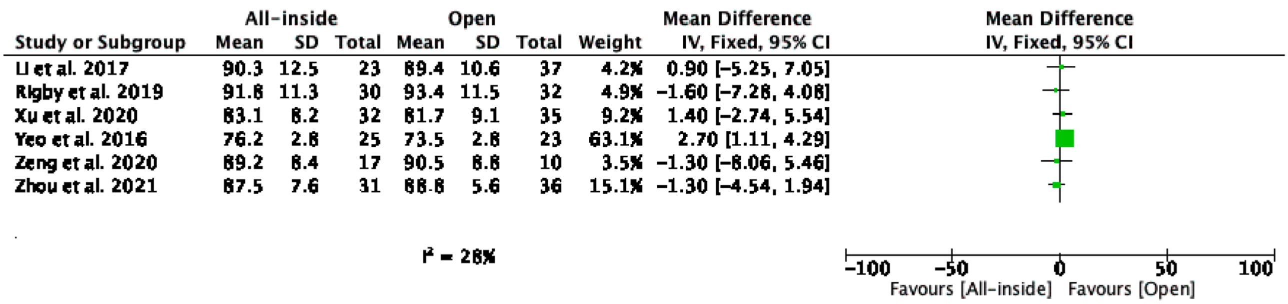

Figure 4

Results of aggregate analysis for the comparison of Karlsson scores between AI and O groups. IV, inverse variance.

patients treated with either arthroscopic or open Broström repair. Although return to activity and sports were not calculated in all studies, they tended to be substantially faster in patients treated with arthroscopic Broström repair. Concerning complications, knot pain and peroneal nerve irritation were common but failed to reach statistical significance. On the other hand, the overall complication rate and impairment of wound healing tended to be lower after all-arthroscopic Broström repair. This implies that all-arthroscopic repair can be seen as a safe technique.

Historically, the open Broström–Gould technique has been the preferred technique for lateral ankle ligament repair. First described in 1980, it comprises direct reconstruction of the ATFL and CFL by enhancement with the joint capsule and use of the inferior extensor retinaculum (13). In recent years, minimally invasive

Table 3 Evaluation of postoperative treatment and rehabilitation protocols.

Reference	Postoperative mobilization	Return to activity*
Zhou *et al.* (37)		
AI & O	Short cast for 2 weeks Ankle brace for 4 weeks Partial weightbearing 4 weeks after surgery, followed by progressive weightbearing	
Woo *et al.* (38)		Full return allowed after 3 months
AI & O	Posterior splint, non-weightbearing for 2 weeks Full weightbearing after 2 weeks, walking boot for 4 weeks	
Zeng *et al.* (39)		
AI & O	Short cast for 2 weeks, followed by walking boot Full weightbearing after 6–12 weeks	
Xu *et al.* (40)		
AI & O	Ankle brace for 6 weeks Partial weight bearing after 4 weeks Full weightbearing after 6 weeks	
Rigby *et al.* (41)		
AI	Below knee splint for 10 days non-weightbearing Short leg cast 50% weightbearing for 10 days Full weightbearing in a walking cast for 7–10 days	Mean time (days) to weightbearing: 12 (9–16) 97% returned to full activity
O	Splint for 10–14 days non-weightbearing Progressive weightbearing in a cast or boot after 3 weeks	Mean time (days) to weightbearing: 22 (20–26) 97% returned to full activity
Li *et al.* (42)		
AI & O	Short leg cast for 2 weeks Ankle brace after 2 weeks Weightbearing permitted after 4 weeks	
Yeo *et al.* (43)		
AI & O	Posterior splint for 2 weeks non-weightbearing Short-leg walking cast for 2 weeks with progressive weightbearing Splint for 2 weeks	Straight running allowed after 8 weeks Full return after 12 weeks
Matsui *et al.* (44)		
AI & O	Splint for several days, immediate weightbearing, followed by ankle brace for 6–8 weeks	
AI		Return (weeks) to daily activity: 5.3 (3–12) Return (weeks) to sports: 16.5 (12–22)
O		Return (weeks) to daily activity: 7.1 (5–12); (P < 0.05) Return (weeks) to sports: 17.1 (13–22); (P = 0.07)

*Data presented as mean (range).

Table 4 Complication rates.

Reference	Complication rate, %	Impaired wound healing, %	Irritation of peroneal nerve, %	Knot pain, %	Revision surgery, %
Zhou *et al.* (37)					
AI	6.5 (2/31)	0.0 (0/31)	3.2 (1/31)	0.0 (0/31)	0.0 (0/31)
O	11.1 (4/36)	0.0 (0/36)	2.8 (1/36)	2.8 (1/36)	0.0 (0/36)
Woo *et al.* (38)					
AI	0.0 (0/26)	0.0 (0/26)	0.0 (0/26	0.0 (0/26)	0.0 (0/26)
O	0.0 (0/26)	0.0 (0/26)	0.0 (0/26)	0.0 (0/26)	0.0 (0/26)
Zeng *et al.* (39)					
AI	11.8 (2/17)	5.9 (1/17)	5.9 (1/17)	0.0 (0/17)	0.0 (0/17)
O	30.0 (3/10)	20 (2/10)	0.0 (0/10)	10.0 (1/10)	0.0 (0/10)
Xu *et al.* (40)					
AI	15.6 (5/32)	0.0 (0/32)	9.4 (3/32)	6.3 (2/32)	0.0 (0/32)
O	14.3 (5/35)	5.7 (2/35)	5.7 (2/35)	0.0 (0/35)	0.0 (0/35)
Rigby *et al.* (41)					
AI	6.7 (2/30)	0.0 (0/30)	3.3 (1/30)	0.0 (0/30)	0.0 (0/30)
O	6.3 (2/32)	0.0 (0/32)	6.3 (2/32)	0.0 (0/32)	0.0 (0/32)
Li *et al.* (42)					
AI	4.3 (1/23)	0.0 (0/23)	0.0 (0/23)	0.0 (0/23)	0.0 (0/23)
O	5.4 (2/37)	0.0 (0/37)	0.0 (0/37)	0.0 (0/37)	0.0 (0/37)
Yeo *et al.* (43)					
AI	20.0 (5/25)	0.0 (0/25)	12.0 (3/25)	8.0 (2/25)	4.0 (1/25)
O	13.0 (3/23)	4.3 (1/23)	8.7 (2/23)	0.0 (0/23)	0.0 (0/23)
Matsui *et al.* (44)					
AI	10.5 (2/19	0.0 (0/19)	10.5 (2/19)	0.0 (0/19)	0.0 (0/19)
O	22.2 (4/18)	16.7 (3/18)	5.6 (1/18)	0.0 (0/18)	0.0 (0/18)

techniques have become more and more popular in order to achieve enhanced wound healing and thereby also accelerated return to activity. One advantage of arthroscopic ligament repair is that intraarticular pathologies such as synovitis or free joint bodies can be addressed simultaneously (18, 41, 45). Ferkel *et al.* reported that 93% of patients treated arthroscopically for lateral ankle instability showed intraarticular abnormalities. In another study by Slater *et al.*, 29% of patients presented with chondral injuries, 24% with loose bodies and 41% showed anterior osteophytes. A biomechanical study showed that arthroscopic repair using suture anchors was able to achieve comparable results to open repair (46). There are few studies that report on biomechanical durability and long-term revision rate after arthroscopic repair. Other important factors to consider regarding the all-arthroscopic technique include the risk of injury to the superficial peroneal or sural nerve and also irritation by suture knots or prominent anchors (23, 47). Studies have shown modifications to avoid irritation by prominent suture anchors such as knotless anchors or bioabsorbable anchors (23, 25). Anatomical studies have tried to define safe zones for ankle arthroscopy to avoid nerve damage (48, 49, 50). Nevertheless, although peroneal nerve irritations occurred a bit more often after all-arthroscopic repair according to the findings of our study, this slight

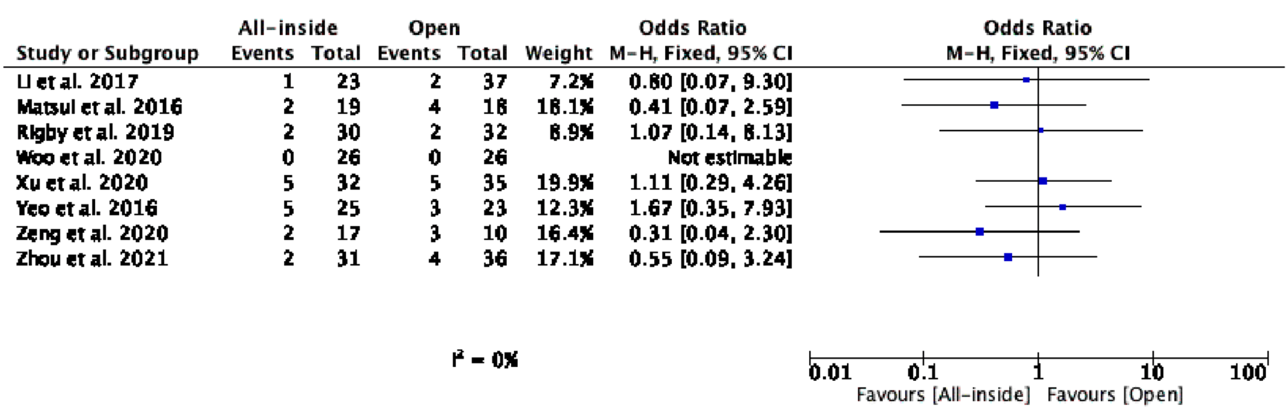

Figure 5
Results of aggregate analysis for the comparison of overall complication rates between BR and ST groups. Numbers for 'events' refer to failure; numbers for 'total' refer to total participants. M–H, Mantel–Haenszel method.

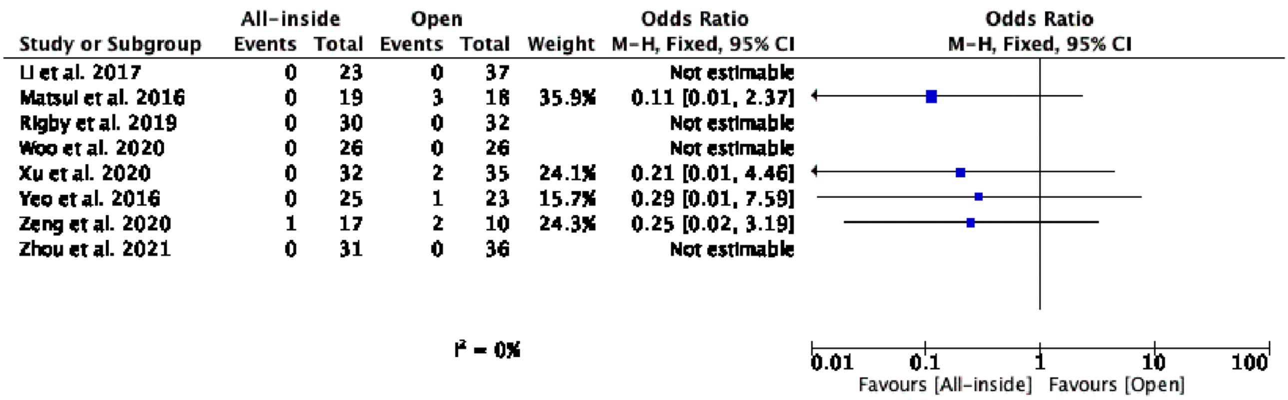

Figure 6
Results of aggregate analysis for the comparison of rates for irritation of woundhealing between BR and ST groups. Numbers for 'events' refer to failure; numbers for 'total' refer to total participants. M–H, Mantel–Haenszel method.

difference was far from statistical significance, indicating that all-arthroscopic technique is a safe procedure.

Through the database search used in this study, only one comparative study contrasting patients treated with all-arthroscopic or arthroscopic-assisted Broström repair has been published (51). Arthroscopic-assisted Broström repair is a type of hybrid technique addressing the intraarticular pathology arthroscopically first and then transitioning to an open Broström repair and combines several advantages of both procedures. Clinical results are excellent, but studies reported a high complication rate (5.3–29.0%) caused by neurological entrapment and prominent implants (23, 47). The comparative study by Guelfi *et al.* (51) showed that AOFAS and VAS scores improved significantly in both groups compared to preoperative levels. However, no significant difference in clinical outcomes between the all-arthroscopic and arthroscopic-assisted Broström group was found. Complication rates were significantly smaller in the all-arthroscopic group with 5.3% vs 40% in the arthroscopic-assisted group. The only complication in the all-arthroscopic group involved a painful ankle plantarflexion deficit > 10 degrees. On the contrary, in the arthroscopic-assisted group, complications included plantarflexion deficit, transient neuritis of the superficial peroneal nerve and prominent suture knots requiring anchor removal. None of the patients required ligament revision surgery, and all patients were able to return to activity without limitations. Although the complication rate is significantly higher in the arthroscopic-assisted group in this study, randomized controlled trials are needed to confirm the potential superiority of all-arthroscopic repair.

Limitations

The present article includes several limitations. First, due to the novelty of all-arthroscopic Broström repair and thus the paucity of studies comparing this method to the more renowned open Broström repair, randomized trials as well as non-randomized cohort studies were included, which might increase the risk for selection bias and confounding. Therefore, MINORS scores were calculated for all non-

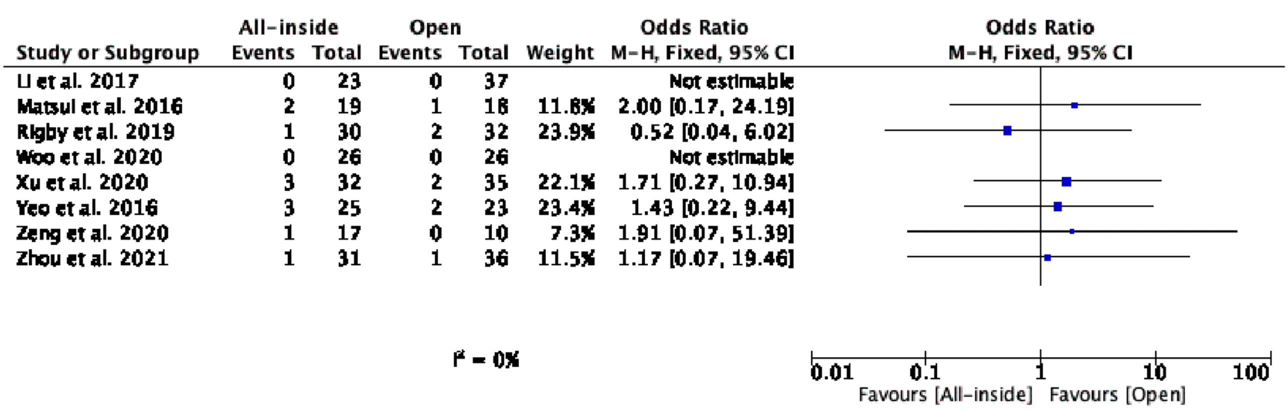

Figure 7
Results of aggregate analysis for the comparison of rates for irritation of peroneal nerve and tendons between BR and ST groups. Numbers for 'events' refer to failure; numbers for 'total' refer to total participants. M–H, Mantel–Haenszel method.

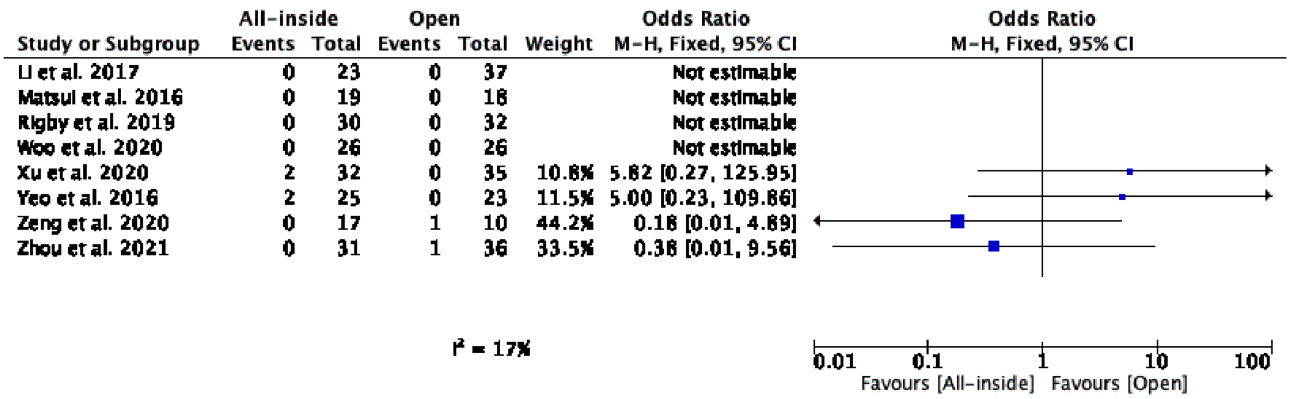

Figure 8

Results of aggregate analysis for the comparison of knot pain rates between BR and ST groups. Numbers for 'events' refer to failure; numbers for 'total' refer to total participants. M–H, Mantel–Haenszel method.

randomized trials to assess risk of bias (36). The seven included non-randomized studies have scores ranging from 17 to 22, indicating tolerable scores, although the risk of bias is evidently present. Loss of points was mainly due to the lack of prospective data collection and absence of prospective calculation of study size. In all seven non-randomized cohort studies, data collection was conducted retrospectively and no adjustment for confounding variables was performed. However, comparison groups were present in all studies.

Secondly, only eight studies were included in total. Moreover, all studies showed high heterogeneity. Altogether, more patients receiving open Broström repair (217 vs 203 in the arthroscopic group) were included in the selected studies. Furthermore, not all mentioned clinical scores were evaluated in all of the studies, which might cause difficulties in drawing valid conclusions. Additionally, a meta-analysis was not performed.

Conclusions

Similar to open repair, all-arthroscopic ligament repair for CLAI is a safe treatment option that yields excellent clinical outcomes.

ICMJE Conflict of Interest Statement

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