



# Do We Need Extensor Retinacular Enhancement on Broström Lateral Ankle Repair? A Systematic Review and Meta-analysis

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## Abstract

**BACKGROUND:** This meta-analysis compared inferior extensor retinaculum (IER) enhancement in Broström-Gould procedure and anatomical Broström repair.

**AIM:** We aim to evaluate functional ankle score (American Orthopaedic Foot and Ankle Society [AOFAS] score and Karlsson score), talar tilt, talar anterior translation, and complications between both groups.

**METHODS:** A comprehensive systematic literature search was carried out using Wiley Library, Scopus, PubMed, ScienceDirect, and Europe PMC databases from inception up until December 19, 2020. While the intervention was IER enhancement, the control was those without IER enhancement. The primary outcome was the functional ankle score (AOFAS and Karlsson score). The secondary outcomes were talar tilt, talar anterior translation, and other complications.

**RESULTS:** There were a total of 298 patients from seven studies included in this systematic review and meta-analysis. IER enhancement was associated with lower AOFAS (mean difference  $-1.115 [-2.197, -0.033]$ ,  $p = 0.043$ ;  $I^2 0\%$ ) during follow-up. Lower Karlsson score was observed in the IER enhancement group (mean difference  $-2.004 [-3.442, -0.567]$ ,  $p = 0.006$ ;  $I^2 3.71\%$ ) during follow-up. Talar tilt (mean difference  $-0.145^\circ [-0.436, 0.146]$ ,  $p = 0.329$ ;  $I^2 0\%$ ) and anterior displacement (mean difference  $-0.109 \text{ mm} [-0.096, 0.314]$ ,  $p = 0.299$ ;  $I^2 0\%$ ) in the two groups were similar on follow-up. The complications were similar in both groups (OR 0.87 [0.40, 1.89],  $p = 0.719$ ;  $I^2 0\%$ ). Meta-regression analysis indicates that the association between IER and AOFAS was not affected by age ( $p = 0.927$ ) and male gender ( $p = 0.930$ ).

**CONCLUSION:** This meta-analysis showed that anterior talofibular ligament repair with non-IER enhancement was non-inferior compared to those with IER enhancement.

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## Introduction

An ankle sprain is one of the most common sports-related injuries with 20% recurrences, and up to 70% of patients still have residual symptoms after conservative treatments [1], [2]. Anterior talofibular ligament (ATFL) is the most frequently injured followed by the calcaneofibular ligament (CFL) [3], [4], [5]. Broström introduced the ATFL repair technique in 1966 [6]. This technique involved approximation and direct sutures of the torn ATFL. Broström also used osseous suture to lateral malleolus on latter publication in the same year. In 1980, Gould presented the idea that the Broström procedure could be enhanced by suturing the talocalcaneal ligament and inferior extensor retinaculum (IER) to the lateral malleolus. Since then, the Broström-Gould procedure [7] has become the gold standard for surgical management of lateral ankle instability [8], [9], [10], [11]. Later, several modifications of the Broström-Gould procedure have been reported, including the use of anchor sutures and the arthroscopic technique [12], [13].

Several biomechanical studies compared Broström and Broström Gould repair; however, the results were inconclusive. Aydogan *et al.* [14] observed that IER enhancement provided biomechanical benefits. Meanwhile, two studies showed similar biomechanical results between non-IER enhancement and IER enhancement [15], [16], [17]. Furthermore, Bell *et al.* [18] conducted a long-term observational study on the Broström repair procedure and showed a satisfactory outcome. Hence, the biomechanical advantages of IER enhancement may not translate into clinical benefits.

Amid the increasing popularity of arthroscopic repair for ankle instability, the question of whether IER enhancement is needed arises [10]. An increasing number of studies showed similar results in terms of clinical outcomes between arthroscopic and open Broström repair. Arthroscopy offers the additional benefit of addressing intra-articular problems at the same time. However, percutaneous IER enhancement during an arthroscopic procedure is technically intricate [19], [20].

The question addressed by this systematic review is whether the Broström-Gould procedure

is clinically superior to Broström repair. We aim to compare functional ankle score (American Orthopaedic Foot and Ankle Society [AOFAS] and Karlsson score), talar tilt, talar anterior translation, and complications between both groups.

## Methods

This study follows the recommendation by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. PROSPERO Registration Number: CRD42021227223.

### **Inclusion and exclusion criteria**

Included studies should meet all of the following criteria: (1) Randomized controlled trial (RCT), prospective or retrospective observational study and (2) comparing IER enhancement and non-IER enhancement technique for chronic lateral ankle instability (CLAI) related to the outcome of interest (there is no language restriction).

The studies were excluded based on the following criteria: (1) Review articles, case reports, commentaries, editorials, letters, animal experiments, cadaveric studies, or technique articles; (2) non-comparative studies; (3) insufficient data, such as conference papers and abstract-only publication; and (4) duplicated studies.

### **Outcome measures**

The intervention was IER enhancement, while the control was those without IER enhancement. The functional ankle score (AOFAS and Karlsson score) was the primary outcome, with mean differences as the effect estimate. The secondary outcome was talar tilt, talar anterior translation, and other complications. The effect estimate for these scores was mean differences for talar tilt and anterior translation; and odds ratio (OR) for the complications.

### **Search strategy and study selection**

A comprehensive systematic literature search was carried out using Wiley Library, Scopus, PubMed, ScienceDirect, and Europe PMC databases from inception up until December 19, 2020, combining the following keywords: (Broström OR Gould OR “extensor retinaculum”) AND (“lateral ankle” OR “ankle instability”). After removing duplicate records, three authors performed independent screening of the title/abstracts of the residual articles based on the inclusion and exclusion criteria.

### **Definition**

CLAI is characterized by functional instability, the subjective complaint of recurring pain, swelling, instability, or giving way sensation of the lateral side of the ankle. The diagnosis was made when ankle instability persists for more than 6 months and confirmed by mechanical instability demonstrated by a pathological manual anterior drawer test (ADT) and talar tilt test [3], [21].

Broström repair is defined as anatomical repair and imbrication of the ATFL as well as the CFL, if required, with or without an anchor [6], [22]. Gould modified this technique by performing IER enhancement in addition to ATFL repair. IER enhancement was performed by suturing the proximal border of the IER to the fibula. This technique was known as Broström-Gould repair. Furthermore, this technique will be known as IER enhancement in this study [7], [23], [24]. Arthroscopic Broström repair is an ATFL repair combined with an arthroscopy procedure or an “all-inside” technique [19], [25].

A variety of rehabilitation protocols is described in Table 1.

The AOFAS ankle-hindfoot scores [26] comprise pain, function, and alignment aspects. A maximum score of 100 points indicates a patient with no pain, full ROM (sagittal and hindfoot), no ankle or hindfoot instability, proper alignment, ability to walk more than six blocks, ability to ambulate on any walking surface, no observable limp, no restriction of daily or recreational activities, and no ambulation devices required.

The Karlsson-Peterson score [27], [28] assesses functional results by evaluating instability, pain, swelling, and stiffness related to activities of daily living, for instance, stair climbing, running, sporting activities, working capability, and leisure time activity. The highest score is 100 points. The visual analog scale [29] is a validated, subjective measure for acute and chronic pain. The score ranged between no pain (0) and worst pain (10).

Perioperative complications include nerve injury, knot pain, poor healing, skin complications (e.g., painful nodule, infection, and abscess), and musculoskeletal complications (e.g., ankle tightness) [30], [31], [32].

### **Quality assessment**

The Newcastle-Ottawa scale was used to assess the quality of studies.

### **Data extraction**

Three reviewers performed independent data extraction from the included studies. The reviewers

Table 1: Baseline characteristics of the included studies

| Author                      | Study design              | Inclusion criteria  | Technique                               | Rehabilitation   | Number of anchor (s)            | Talar tilt (mm)   | Anterior drawer test (mm)  | Age  | Male | BMI  | Mean follow-up (months) | NOS |
|-----------------------------|---------------------------|---|---|--|---------------------------------|---|--|------|------|------|-------------------------|-----|
| Jeong <i>et al.</i> (2014)  | Prospective cohort        | CLAI, operated between February 2011 and October 2012           | Arthroscopic BP+IER vs. arthroscopic BP | <ul style="list-style-type: none"> <li>• Non-weight-bearing was maintained for 6 weeks after surgery.</li> <li>• Short leg cast immobilization was maintained for 4 weeks after surgery.</li> <li>• Ankle ROM exercises were allowed for 2 weeks with protection of ankle orthosis.</li> <li>• Six weeks after surgery begins partial weight-bearing, proprioception, and peroneal muscle strengthening exercise.</li> <li>• Light exercises began after 3 months and gradually returned to their normal sports activities</li> </ul>  | 1 vs. 1                         | Arthroscopic BP+IER<br>5.0±2.<br>Arthroscopic BP<br>4.9±0.9 | (Talar anterior translation)<br>Arthroscopic BP+IER<br>4.6±1.9<br>Arthroscopic BP<br>4.9±0.8 | 26.2 | 51.6 | N/A  | 19.5 vs. 18.9           | 7   |
| Yeo <i>et al.</i> (2016)    | Randomized clinical trial | CLAI, operated between August 2012 and July 2014                | Arthroscopic BP vs. Open BP+IER         | <ul style="list-style-type: none"> <li>• All patients were placed in a well-padded posterior splint with the foot in slight dorsiflexion and kept non-weight-bearing until 2 weeks.</li> <li>• Short leg walking cast for next 2 weeks and protected progressive weight-bearing was then allowed.</li> <li>• During week 4–6, half-removed cast or splint was applied and started on gentle active assisted ROM of the ankle and peroneal strengthening exercise.</li> <li>• Eight weeks postoperatively, the patient began running and functional activities.</li> <li>• Cutting and sport-specific drills were started by week 12</li> </ul> | 1 vs. 1                         | Arthroscopic BP<br>3.9±1.5<br>Open BP+IER<br>3.8±3.6        | Arthroscopic BP<br>6.7±1.3<br>Open BP+IER<br>6.8±2.1   | 34.8 | 39.6 | N/A  | 12 vs. 12               | 9   |
| Araoye <i>et al.</i> (2017) | Retrospective cohort      | CLAI, operated between 2006 and 2016                            | Arthroscopic BP+IER vs. Arthroscopic BP | N/A  | Suture anchor vs. Direct suture | N/A   | N/A  | 40   | 27.8 | 31.9 | 11.8                    | 7   |
| Li <i>et al.</i> (2017)     | Prospective cohort        | CLAI, operated between January 2012 and August 2014             | Arthroscopic BP vs. Open BP+IER         | <ul style="list-style-type: none"> <li>• Isometric contraction from the day after surgery.</li> <li>• The ankle was immobilized in a neutral position by short leg cast</li> <li>• Two weeks after the surgery, the cast was changed to an ankle brace and passive ROM was encouraged</li> <li>• Weight-bearing was permitted after 4 weeks</li> </ul>   | 1 or 2 vs. 1 or 2               | N/A   | N/A  | 29.3 | 78.3 | 23.7 | 39.7 vs. 35.5           | 7   |
| Gang <i>et al.</i> (2020)   | Retrospective cohort      | CLAI, operated between January 2014 and January 2017            | Arthroscopic BP vs. Open BP+IER         | <ul style="list-style-type: none"> <li>• Short leg cast was applied after surgery and isometric contraction was trained.</li> <li>• After 2 weeks, short leg cast was removed and replaced by functional exercise brace, and partial weight-bearing was started. (active and passive ROM exercise was initiated)</li> <li>• Six weeks after surgery, the patient began balance training, endurance training, and transition to full weight-bearing.</li> </ul>   | 1 vs. 1                         | Arthroscopic BP<br>3.3±0.8<br>Open BP+IER<br>3.1±0.4        | (Anterior displacement of Talus)<br>Arthroscopic BP<br>3.2±0.4<br>Open BP+IER<br>3.3±0.5     | 38.4 | 70.1 | N/A  | 26 vs. 26               | 9   |
| Xu <i>et al.</i> (2020)     | Retrospective cohort      | CLAI accompanied by OLT, operated between May 2015 and May 2017 | Arthroscopic BP vs. Open BP+IER         | <ul style="list-style-type: none"> <li>• The ankle was protected by an ankle brace for 6 weeks.</li> <li>• Isometric contraction of muscle groups was allowed from the day after surgery</li> <li>• Passive and active ROM was allowed from the 7<sup>th</sup> day after surgery under ankle brace.</li> <li>• Partial weight-bearing began from the 5<sup>th</sup> week after surgery and full weight-bearing began from 7<sup>th</sup> week after surgery</li> <li>• The patient could return to high-impact physical activities for 6 months after surgery</li> </ul>   | 1 or 2 vs. 1 or 2               | N/A   | N/A  | 34.8 | 73.1 | 23.7 | 36.5 vs. 39.1           | 9   |

(Contd...)

Table 1: (Continued)

| Author                    | Study design         | Inclusion criteria                                | Technique                       | Rehabilitation   | Number of anchor (s) | Talar tilt (mm)                                      | Anterior drawer test (mm)                            | Age  | Male | BMI | Mean follow-up (months) | NOS |
|---------------------------|----------------------|---|---------------------------------|--|----------------------|--|--|------|------|-----|-------------------------|-----|
| Zeng <i>et al.</i> (2020) | Retrospective cohort | CLAI, operated between January 2013 and June 2015 | Arthroscopic BP vs. open BP+IER | <ul style="list-style-type: none"> <li>The short leg cast was applied until 2 weeks after surgery.</li> <li>After 2 weeks, short leg cast was removed. Flexion and extension of hip and knee were encouraged</li> <li>At 3–6 weeks after surgery, patients began walking in a boot, and strengthening exercises of the whole lower extremity.</li> <li>The flexion and extension of the ankle joint were passively performed.</li> <li>At 6–12 weeks after surgery, balance training and full weight-bearing were performed</li> </ul> | 1 vs. 1              | Arthroscopic BP<br>2.7±1.2<br>Open BP+IER<br>2.4±1.3 | Arthroscopic BP<br>3.3±1.3<br>Open BP+IER<br>2.8±1.1 | 29.7 | 81.5 | N/A | 36 vs. 36               | 9   |

BMI: Body mass index, ROM: Range of motion, NOS: Newcastle Ottawa Scale, CLAI: Chronic lateral ankle instability, BP: Broström procedure, IER: Inferior extensor retinaculum, vs.: Versus

were not blinded to the authors and institution of the studies while undergoing review. Discrepancies were resolved by consensus among the three reviewers. Variables included authors, study design, age, sex, body mass index (BMI), operating technique, rehabilitation protocol, number of anchors, AOFAS, talar tilt, ADT, and follow-up.

### Statistical analysis

Meta-analysis was performed using STATA 16. We performed a restricted maximum likelihood random effects meta-analysis to calculate the mean difference and 95% confidence interval of AOFAS, Karlsson score, talar tilt, and anterior drawer between the intervention and control groups. We performed a DerSimonian-Laird random effects meta-analysis to calculate the OR and 95% confidence interval for complications. I-squared ( $I^2$ ) and Cochran Q test were carried out to assess interstudy heterogeneity, in which  $I^2 > 50\%$  and  $p < 0.10$  indicate significant heterogeneity. Meta-regression analysis was performed for age, male, and BMI as covariates. We performed a sensitivity analysis by excluding a study with potential selection bias.

## Results

### Baseline characteristics

A total of 980 studies were obtained after duplication removal. After screening through the title and abstract according to the inclusion and exclusion criteria, 25 studies were assessed for eligibility. Ultimately, this systematic review and meta-analysis included 298 patients from seven studies (Figure 1). Baseline characteristics of the included studies are displayed in Table 1.

ATFL identified using arthroscopic examination was repaired with an “all-inside”

arthroscopic technique without IER enhancement. Unidentified ATFL was repaired by an open technique with IER enhancement.

### Outcomes

IER enhancement was associated with lower AOFAS (mean difference  $-1.115$  [ $-2.197$ ,  $-0.033$ ],  $p = 0.043$ ;  $I^2$  0%,  $p = 1.000$ ) (Figure 2a) during follow-up. Lower Karlsson score was observed in the IER enhancement group (mean difference  $-2.004$  [ $-3.442$ ,  $-0.567$ ],  $p = 0.006$ ;  $I^2$  3.71%,  $p = 0.656$ ) (Figure 2b) during follow-up. Talar tilt (mean difference  $-0.145^\circ$  [ $-0.436$ ,  $0.146$ ],  $p = 0.329$ ;  $I^2$  0%,  $p = 0.808$ ) (Figure 3a) and anterior displacement (mean difference  $-0.109$  mm [ $-0.096$ ,  $0.314$ ],  $p = 0.299$ ;  $I^2$  0%,  $p = 0.769$ ) in the two groups were similar on follow-up (Figure 3b). The complications were similar in both groups (OR 0.87 [ $0.40$ ,  $1.89$ ],  $p = 0.719$ ;  $I^2$  0%,  $p = 0.693$ ) (Figure 4).

### Arthroscopic with non-IER enhancement versus open IER enhancement

AOFAS and Karlsson score between arthroscopic non-IER enhancement technique and open IER enhancement technique showed similar results with mean difference  $-1.11$  [ $-2.20$ ,  $-0.03$ ],  $p = 0.85$ ;  $I^2$ : 0%,  $p = 1.000$  and mean difference  $-2.00$  [ $-3.44$ ,  $-0.57$ ],  $p = 0.66$ ;  $I^2$ : 3.71%,  $p < 0.001$ , respectively.

### Sensitivity analysis

Sensitivity analysis was performed to exclude Li *et al.* [33] study due to high risk of selection bias. In this analysis, IER enhancement was associated with lower AOFAS (mean difference  $-1.128$  [ $-2.242$ ,  $-0.014$ ],  $p = 0.047$ ;  $I^2$  0%,  $p = 1.000$ ) and Karlsson score (mean difference  $-2.052$  [ $-3.563$ ,  $-0.542$ ],  $p = 0.008$ ;  $I^2$  5.27%,  $p = 0.518$ ). Talar tilt (mean difference  $-0.145^\circ$  [ $-0.436$ ,  $0.146$ ],  $p = 0.329$ ;  $I^2$  0%,  $p = 0.808$ ) and



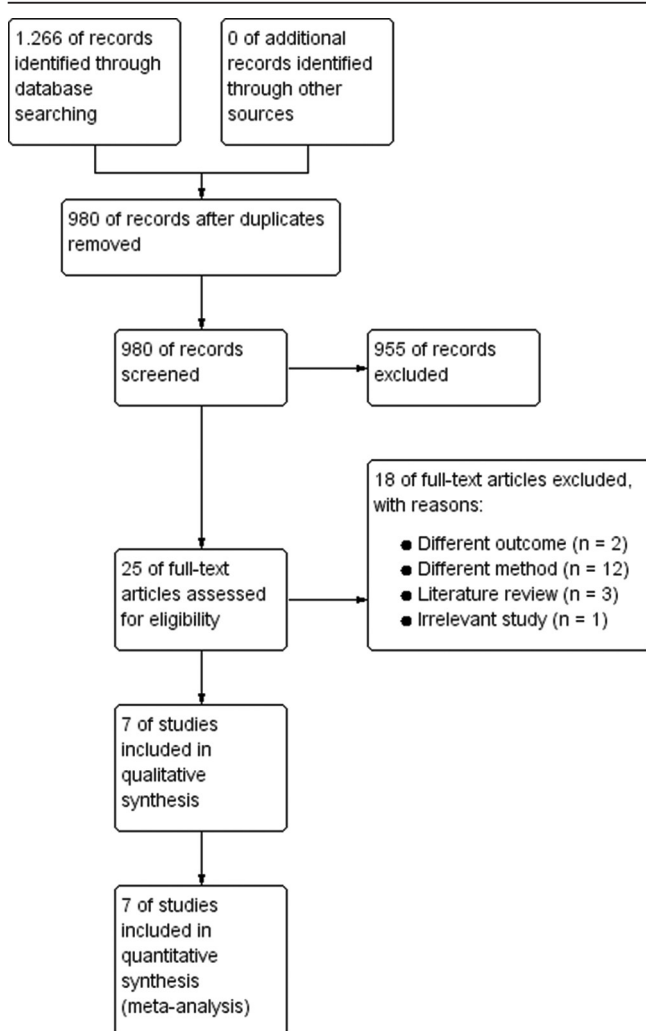


Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Flowchart

anterior displacement (mean difference  $-0.109$  mm [ $-0.096, 0.314$ ],  $p = 0.299$ ;  $I^2: 0\%$ ,  $p = 0.769$ ) in the two groups were similar. The complications were similar in both groups (OR  $0.83$  [ $0.36, 1.90$ ],  $p = 0.659$ ;  $I^2: 0\%$ ,  $p = 0.545$ ).

### Meta-regression

Meta-regression analysis indicates that the association between IER and AOFAS was not affected by age ( $p = 0.927$ ) and male gender ( $p = 0.930$ ).

### Publication bias

The funnel plot was symmetrical for AOFAS (Figure 5), talar tilt, and complications. Egger's test was not significant for AOFAS ( $p = 0.938$ ), Karlsson score ( $p = 0.140$ ), talar tilt ( $p = 0.483$ ), and complications ( $p = 0.391$ ).

## Discussion

The main clinical outcomes (AOFAS and Karlsson score) were worse in ATFL repair with IER enhancement, while talar tilt, anterior displacement, and complications were similar in both groups. The mean follow-up in the included studies ranged from 11.8 months to 39.7 months. The pooled effect estimates have a low heterogeneity; thus, the findings are similar despite differences in characteristics, arthroscopic or open surgery, and rehabilitation protocols. The low heterogeneity in pooled analysis indicates consistency. Regarding the difference between arthroscopic and open techniques, two studies compare arthroscopic non-IER enhancement and arthroscopic IER enhancement. Jeong *et al.* [24] showed no significant difference in terms of post-operative AOFAS score between the two groups. Araoye *et al.* [30] did not evaluate the AOFAS score in their study.

Four studies compared arthroscopic non-IER enhancement techniques and the open Broström procedure with the IER enhancement technique. There was no statistically significant difference in terms of AOFAS and Karlsson scores among the two groups.

A study by Li *et al.* [33] compared arthroscopic examination in the arthroscopic repair group with the open repair group, resulting in different patient selections between groups. Patients with unidentified ATFL remnants were operated on using the IER enhancement technique [34]. This may affect the outcome as there is a difference in ATFL quality between groups. To test the robustness of the pooled analysis, we performed a sensitivity analysis by removing Li *et al.* [33] study and the benefit in terms of AOFAS and Karlsson score remains statistically significant.

Even though there is no indication of small-study effects assessed by funnel plot and Egger's test, we cannot rule out publication bias due to assessment in  $<10$  studies. Several studies showed that age might affect ligament healing [35], [36]. However, meta-regression analysis indicates that the change in the AOFAS score does not vary by age or gender. It may be caused by the patient's age in these studies distributed normally. Several confounding variables have been excluded or controlled in its studies, such as an osteochondral lesion, ankle fracture, and subtalar joint sprain. Unfortunately, we cannot provide comprehensive meta-regression analysis due to limited studies, and confounders are not reported adequately by the studies. The other confounders included CFL repair, periosteal flap, anchors, and hyperlaxity. Rehabilitation protocols vary among the included studies and may potentially confound. Nevertheless, despite the inadequate address of these confounders, 0% heterogeneity in most outcomes indicates that the findings are generalizable.

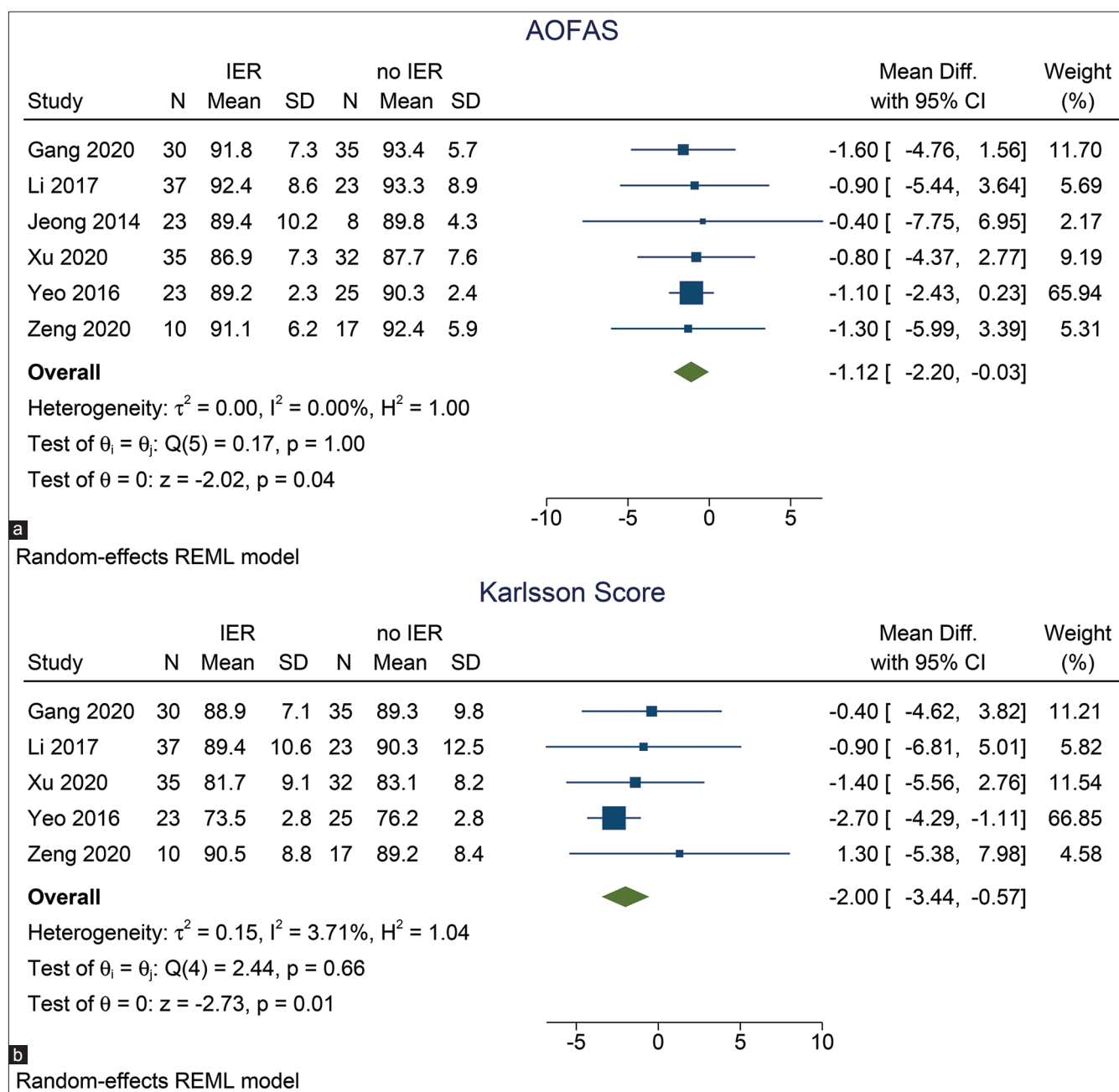


Figure 2: Functional outcome. AOFAS (a) and Karlsson (b). AOFAS: American Orthopaedic Foot and Ankle Society

Meta-analysis shows that ATFL repair with non-IER enhancement was better than IER enhancement in AOFAS and Karlsson score. These findings are supported by several studies, including those exploring biomechanical comparisons in cadaveric studies. There are no significant differences in anterior displacement and talar tilt outcome between ATFL repair with and without IER enhancement [15], [16], [17]. Although a cadaveric study shows some IER enhancement benefits [14], it may not translate into clinical outcomes.

The minimal clinically important difference (MCID) of AOFAS and Karlsson score in CLAI has not yet been established. The included studies did not report the proportion of patients achieving MCID in both groups, so we cannot compare the ratio for achieving

MCID. The advantage of functional score remains to be investigated. However, due to only slight differences, it is not likely that the advantage of non-IER enhancement in this pooled analysis will be clinically relevant. Thus, non-IER enhancement is non-inferior compared to IER enhancement.

Performing IER enhancement is not always feasible in these conditions: (1) Missing IER; (2) X-shaped IER; and (3) far distance to the fibular tip [24]. Furthermore, the correlation between IER and superficial peroneal nerve should be considered [37], [38].

**Clinical implication**

Meta-analysis showed that ATFL repair with non-IER enhancement was not inferior compared

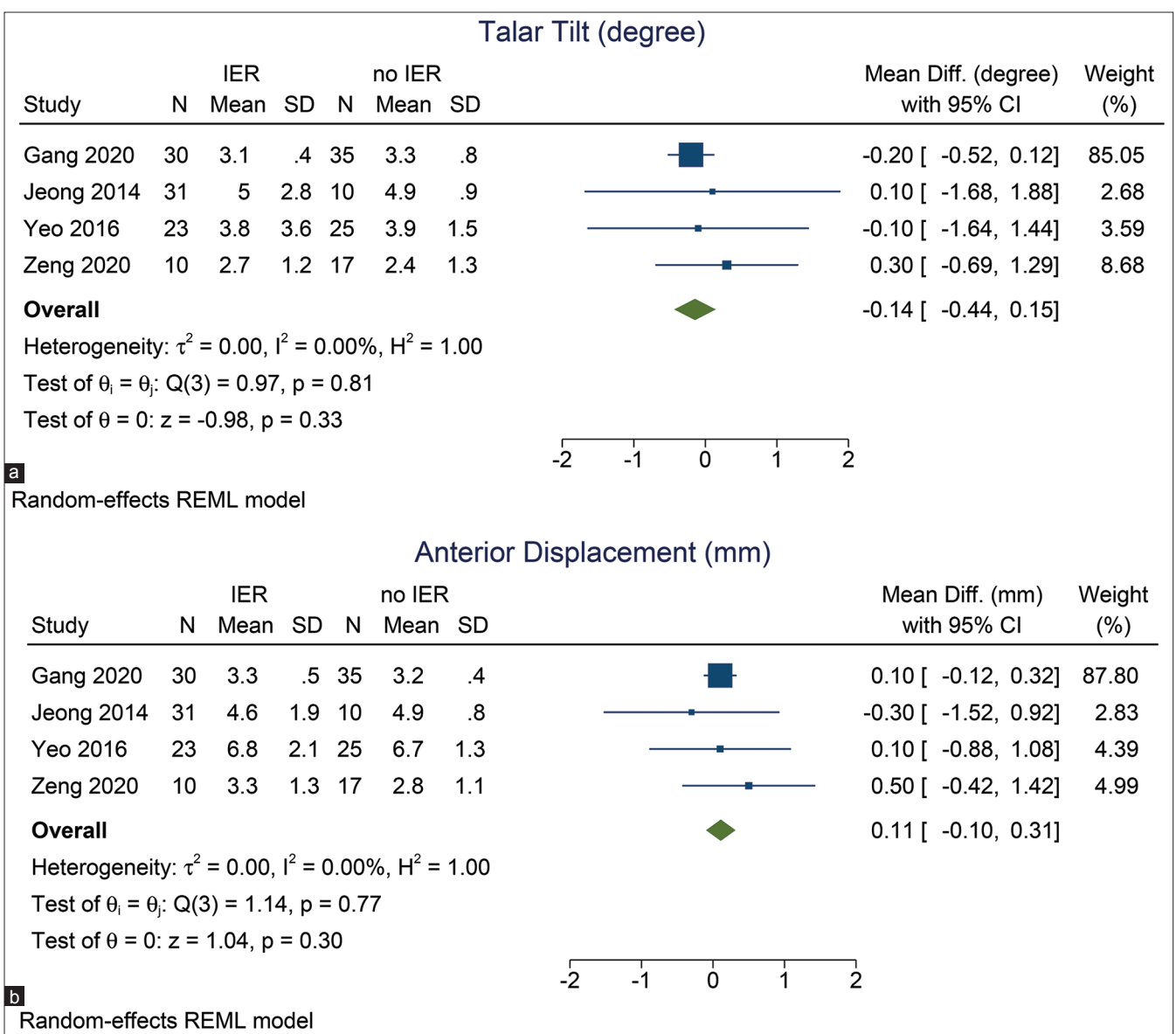


Figure 3: Radiologic outcome. Talar tilt (a) and anterior displacement (b)

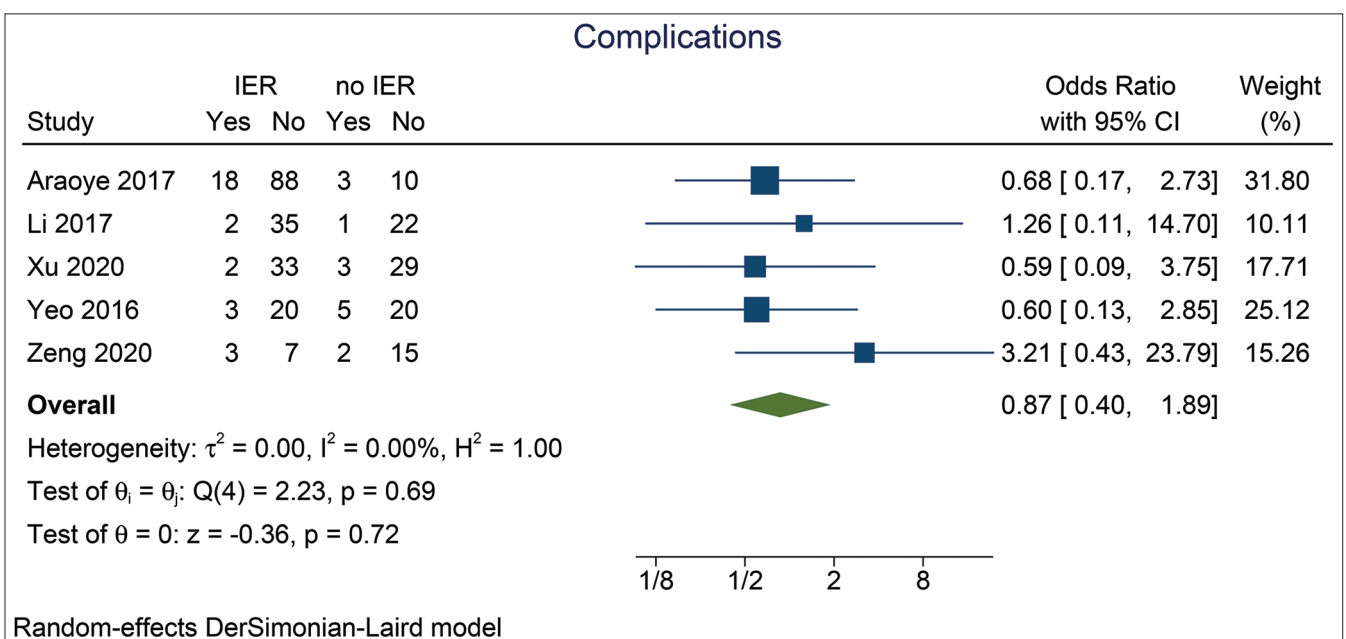


Figure 4: Complications

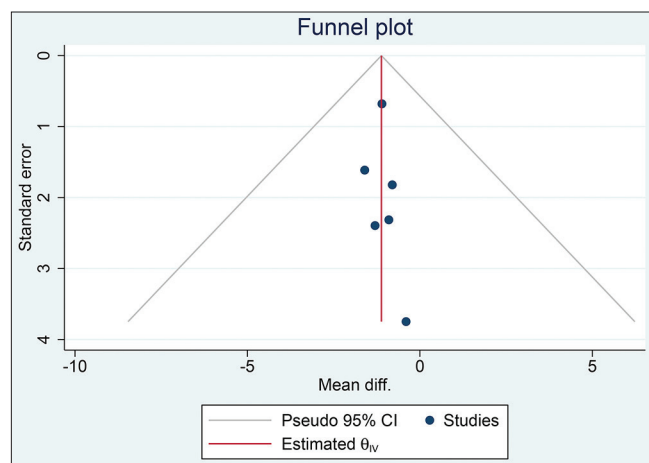


Figure 5: Funnel plot analysis for AOFAS. AOFAS: American Orthopaedic Foot and Ankle Society

to those with IER enhancement. The authors of this study recommend non-IER enhancement as the primary surgical approach for managing CLAI. IER enhancement can be performed whenever ATFL is unidentified or when the quality of the ATFL remnant is low.

### Limitations

The limitation of this study includes low certainty of the evidence of studies. It is because most of the studies are observational and retrospective, thus were prone to biases. Only one RCT generates a higher certainty of the evidence. Many of the studies did not report potential confounders, which may affect the result. Further study with a randomized clinical trial design is recommended with appropriate control of confounders, such as CFL injury/repair, periosteal flap, anchor utilization, and hyperlaxity patient.

### Conclusion

This meta-analysis showed that ATFL repair with non-IER enhancement was non-inferior compared to those with IER enhancement.

### Declaration

#### Consent for publication

All authors approved the final version of the manuscript.

### Availability of data and materials

Data are available at the reasonable request.

### Authors' contributions

John Butarbutar: Conceptualization, data curation, formal analysis, investigation, validation, writing – original draft, and writing – review and editing. Irvan: Data curation, formal analysis, investigation, validation, and writing – original draft. Michael Anthonius Lim: Data Curation, Formal analysis, investigation, validation, and writing – original draft. Raymond Pranata: Data Curation, formal analysis, investigation, validation, writing – original draft, and writing – review and editing.

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