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Comparison of arthroscopic and open Brostrom-Gould surgery for chronic ankle instability: a systematic review and meta-analysis



Binzhi Zhao^{1†}, Qingnan Sun¹, Xiaopei Xu¹, Yang Liu¹, Yanrui Zhao^{1†}, Yulin Gao¹ and Junlin Zhou^{1*}

Abstract

Background Approximately 20% of acute ankle sprains progress to chronic lateral ankle instability (CLAI) requiring surgical intervention. There has been growing interest among surgeons regarding whether arthroscopic techniques can replace open Brostrom-Gould surgery in treating CLAI. The purpose of this study was to pool the results of multiple studies comparing the treatment effects of these two fixation approaches.

Methods Our study involved thorough searches across multiple electronic databases, including PubMed, Cochrane, Embase, and Web of Science, to identify all relevant publications on CLAI that were repaired using the arthroscopic or open Broström-Gould technique. Through a comprehensive meta-analysis, we evaluated several outcomes, including post-operative function, radiological measurements, complications, and time efficiency.

Result A total of 686 patients from 11 studies were included in the analysis. Among them, 351 patients underwent open repair, and 335 underwent arthroscopic Brostrom-Gould surgery. The present study revealed that arthroscopic and open Brostrom-Gould techniques demonstrated no significant differences in talar tilt, talar anterior translation, complication rate, and time to return to previous level of activity. Furthermore, no significant differences were observed in AOFAS, K–P, VAS, and Tegner scores at the 2-year follow-up. However, significant differences were noted between the two surgical approaches in terms of early weight-bearing (WMD = -1.33 weeks, 95% CI = [-1.91, -0.76], P=0.17, $I^2=40\%$), as well as AOFAS scores (WMD = 1.00, 95% CI = [0.05, 1.95], P=0.73, $I^2=0\%$), K–P scores (WMD = 1.57, 95% CI = [0.49, 2.64], P=0.15, $I^2=47\%$), and VAS scores (WMD = -0.15, 95% CI = [-0.60, 0.29], P<0.08, $I^2=61\%$) within the first postoperative year.

Conclusions Our findings support that arthroscopic repair yields comparable outcomes to open surgery. Consequently, we advocate for adopting arthroscopic repair as a preferred alternative to the conventional open Broström-Gould procedure for treating chronic lateral ankle instability.

Keywords Chronic lateral ankle instability, Open, Arthroscopic, Brostrom-Gould, Repair, Meta-analysis

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Introduction

The most common injury to the ankle joint is an ankle sprain, comprising for approximately 85% of all ankle injuries, with the majority being lateral inversion sprains [1]. The injury primarily involves the anterior talofibular ligament (ATFL), and the extent of damage to the ATFL

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ranges from mild stretching to severe complete tear [2]. Most patients achieve favorable treatment outcomes with temporary activity restriction and functional rehabilitation. However, a study indicated that around 20% of individuals who suffer from acute ankle sprains may develop chronic lateral ankle instability (CLAI), necessitating potential surgical treatment [3].

Some studies have demonstrated that the Broström-Gould technique, which involves repairing the ATFL repair with an inferior extensor retinaculum augmentation, has shown favorable outcomes in restoring lateral ankle stability [4-6]. The open Broström-Gould technique has long been considered the gold standard for treating CLAI [7–9]. Recently, there has been a rising interest in adopting arthroscopic Brostrom-Gould as a substitute for conventional open Brostrom-Gould surgery. Compared to open surgery, the arthroscopic technique has the advantage of easily detecting intraarticular abnormalities and being able to address them while repairing the ligament [10-12]. It has been reported to achieve similar or even superior clinical scores and faster rates of motion recovery [13, 14]. Additionally, it may facilitate an accelerated postoperative rehabilitation process [15]. However, a study suggests that while arthroscopic surgery is popular, there is no evidence proving it to be more beneficial than traditional open surgery [16].

There is ongoing controversy regarding the potential of arthroscopic techniques to replace open Brostrom-Gould surgery as a treatment option for CLAI. Therefore, this meta-analysis aims to pool the results of multiple studies comparing the treatment effects of these two fixation approaches.

Materials and methods

Search strategy

The present study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for reporting systematic reviews and meta-analyses [17]. We registered the review protocol in the PROSPERO database (CRD42023406427) [18]. The last search date was July 5, 2023, and the PubMed, the Cochrane Library, Embase and Web of Science databases were searched. The search procedure is based on the following keywords: ("Arthroscopic" OR "Arthrosc*" OR "Minimally invasive surg*" OR "Endoscop*") AND ("Brostrom" OR "Modified Brostrom" OR "Brostrom-Gould" OR "inferior extensor retinaculum" OR "IER"). We initially screened the title and abstract of each article to determine eligibility, followed by a full-text assessment of those meeting the criteria. Moreover, we thoroughly examined the references cited in the included articles for completeness.

Inclusion and exclusion criteria

This systematic review and meta-analysis included comparative studies on arthroscopic and open Bröstrom-Gould procedure in recurrent ankle sprains and chronic ankle instability, defined as persisting instability symptoms after 6 months of conservative treatment, positive anterior drawer test, and isolated grade III chronic ATFL and CFL injuries confirmed by magnetic resonance imaging (MRI). Studies including patients with previous ankle fractures, affected ankle surgery, severe ankle arthritis, combined neuromuscular diseases, and generalized ankle laxity were excluded. Arthroscopic Bröstrom-Gould procedure was considered the experimental group, while open repair was the control intervention. Outcomes measured included functional scores (AOFAS, K-P VAS, and Tegner scores), radiological outcome (anterior drawer and talar tilt), complication rate, duration of operation, time to return to weightbearing, and sport.

Additionally, we included studies with high quality and excluded cases, reviews, and studies with low homogeneity. There were no restrictions on language.

Quality assessment

Two authors evaluated the quality of the included studies using the Cochrane Reviewer's Handbook [19]. This study assessed the risk of bias in seven domains, which include random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other sources of bias. Each criterion was assessed for low, unclear, or high degree of bias. Nonrandomized controlled trials are evaluated according to Newcastle-Ottawa Scale (NOS), which mainly includes selection, comparison and outcome [20]. Research scoring seven or more points is considered to be of high quality. The assessments of the included studies were conducted independently by two reviewers (B.Z.Z. and Q.N.S.), and any disagreements were resolved by consulting a third reviewer (J.L.Z.).

Data extraction

Relevant information from the included literature, including first author, publication date, sample size, patient age and gender, surgical approach, and follow-up time, was extracted independently by two reviewers. The outcome measures were the AOFAS scores, K–P scorers, VAS pain scores, Tegner scores, anterior drawer, talar tilt, complication rate, duration of operation, time to return to weightbearing and sport. When standard deviations were missing from studies, we attempted to contact the authors of articles by email to obtain relevant metrics. Medians and ranges were converted without means and SDs, as Wan et al. recommended [21]. Disagreements during the extraction process were resolved through consultation with a third investigator (J.L.Z).

Statistical analysis

Data were analyzed using Review Manager (RevMan 5.4.1, Nordic Cochrane Center, Copenhagen, Denmark) for this meta-analysis. Mean difference (MD) with 95% confidence intervals (95% CI) was used for continuous data analysis, while odds ratios (OR) with 95% CI were used for dichotomous data analysis. To determine heterogeneity, we used the I² tests. If I² > 50% and P < 0.10, it indicates high heterogeneity. In cases of significant heterogeneity, we used fixed-effect models. Conversely, we used fixed-effect models when heterogeneity was low.

Results

Study selection

The PRISMA flow diagram (Fig. 1) illustrates the literature search and selection process. We identified 673 relevant articles by searching electronic databases. Eleven articles were selected for this meta-analysis, all of which compared the effect of arthroscopic and open Brostrom-Gould procedures for the treatment of CLAI.

Study characteristics

The meta-analysis comprised eleven studies that compared the efficacy of arthroscopic and open Brostrom-Gould procedures for CLAI. These studies included two randomized controlled trials, two prospective and seven retrospective cohort studies, with a total of 686 patients

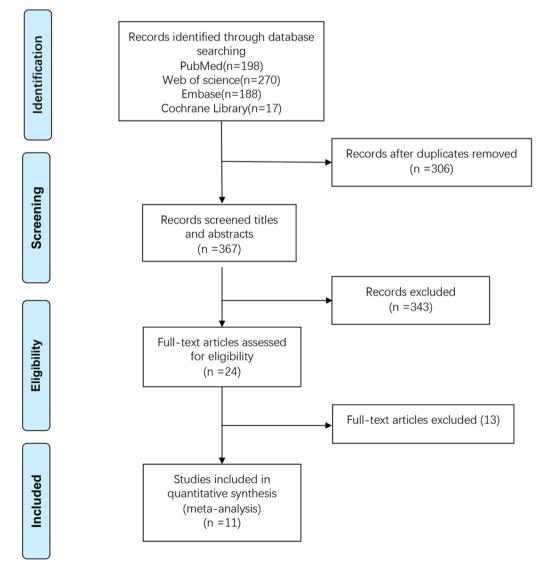


Fig. 1 Flow diagram of screening the included studies in the meta-analysis

(395 males and 291 females), of which 335 underwent arthroscopic repair, and 351 underwent open Brostrom-Gould (Table 1).

Risk-of-bias assessment

The risk of bias items for each included study is shown in Fig. 2. Furthermore, the seven retrospective and two prospective cohort studies were evaluated using the Newcas-tle–Ottawa Scale and were all rated as high quality, with scores ranging from 7 to 9, as shown in Table 2.

Functional outcome

AOFAS score

Three studies evaluated the postoperative 3-month AOFAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 25, 27]. The pooled results in Fig. 3a indicated no significant difference between two surgical techniques (WMD=3.46, 95% CI=[-0.85, 7.77], P=0.12), with high heterogeneity (P=0.0002, $I^2=88\%$). Four studies evaluated the postoperative 6-month AOFAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23–25, 31]. The pooled results in Fig. 3b demonstrated a significant difference between two surgical techniques (WMD=5.54, 95% CI=[1.08, 9.99], P=0.11), with high

 Table 1
 General characteristics of the included studies

heterogeneity (P=0.02, $I^2=67\%$). Four studies evaluated the postoperative 1-year AOFAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23–25, 29]. The pooled results in Fig. 3c demonstrated a significant difference between two surgical techniques (WMD=1.00, 95% CI=[0.05, 1.95], P=0.04), with no heterogeneity (P=0.73, $I^2=0\%$).

Seven studies evaluated the postoperative 2-year AOFAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [13, 23–25, 27, 28, 32]. The pooled results in Fig. 3d indicated no significant difference between two surgical techniques (WMD=0.11, 95% CI=[-0.78, 1.00], P=0.81), with no heterogeneity (P=0.72, $I^2=0\%$).

K–P score

Two studies evaluated the postoperative 6-month K–P score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 24, 29]. The pooled results in Fig. 3e demonstrated a significant difference between two surgical techniques (WMD=1.43, 95% CI=[0.32, 2.54], P=0.01), with no heterogeneity (P=0.90, $I^2=0\%$).

Three studies evaluated the postoperative 1-year K–P score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 29, 31]. The pooled results in

References	Study design	Surgical approach	Number	Male/female	Age	BMI (Kg/m²)	Follow-up (months)
Baek [22]	RCC	Open	34	23/11	21.1±3.5	24.1 ± 3.5	70.9±39.0
		Arthroscopic	31	20/11	22.9 ± 4.4	25.2 ± 3.6	28.7 ± 5.4
Wang [23]	PCS	Open	31	10/21	28.6 ± 8.1	22.9 ± 5.1	44.9±48.6
		Arthroscopic	30	12/18	27.2 ± 7.7	23.8 ± 4.7	57.7±53.7
Wang [<mark>24</mark>]	RCC	Open	50	34/16	31.92 ± 4.77	22.38 ± 2.29	23.52±8.37
		Arthroscopic	49	32/17	31.71 ± 4.99	21.84 ± 2.4	25.0 ± 8.48
Hou [25]	RCT	Open	34	17/17	28.6 ± 4.8	21.7 ± 2.5	22.5±19.6
		Arthroscopic	36	17/19	28.3 ± 5.4	21.0 ± 3.1	19.8±17.9
Zhou [13]	RCC	Open	36	23/13	31.36 ± 7.79	23.63 ± 2.64	33.06 ± 6.82
		Arthroscopic	31	20/11	33.42 ± 6.4	24.42 ± 1.87	29.69 ± 3.40
Woo [<mark>26</mark>]	RCC	Open	26	16/10	31.5 ± 10.3	27.2 ± 5.2	12
		Arthroscopic	26	16/10	33.4 ± 10.6	26.6 ± 4.5	12
Yi [27]	RCC	Open	30	22/8	37.3	NA	26
		Arthroscopic	35	24/11	39.3	NA	26
Rigby [1]	RCC	Open	32	14/18	37.73 (9–72)	NA	44.4
		Arthroscopic	30	9/21	47.89 (14–83)	NA	15.6
Li [28]	PCS	Open	37	29/8	28.7 ± 8.7	23.9 ± 2.5	35.5±9.9
		Arthroscopic	23	18/5	30.3 ± 10.1	23.3 ± 2.9	39.7±10.3
Yeo [29]	RCT	Open	23	12/11	34.3 (17–52)	NA	12
		Arthroscopic	25	7/18	35.2 (19–54)	NA	12
Matsui [<mark>30</mark>]	RCC	Open	18	8/10	24 (13–56)	NA	12
		Arthroscopic	19	12/7	28 (8–59)	NA	12

RCC Retrospective case-cohort; PCS Prospective case-cohort; RCT Randomized controlled trial

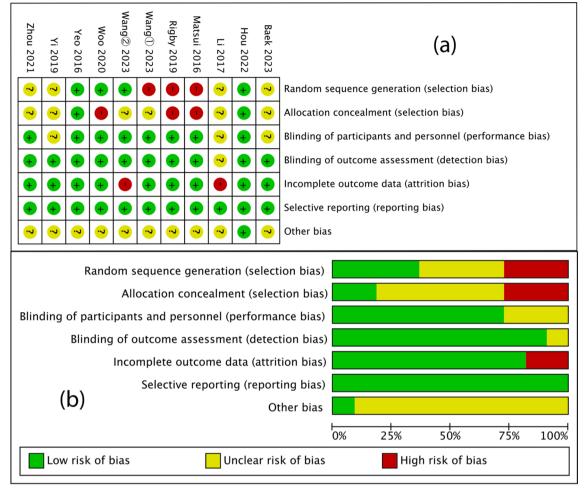


Fig. 2 Review authors' judgments about each risk of bias item for each included study. a. Risk of bias summary; b. risk of bias graph presented as percentages

Table 2 Quality assessment for the nine cohort studies according to Newcastle–Ottawa sca	le (NOS)
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Study	Year	S				с		Е			Total score
		S1	S2	S3	S 4	C1	C2	E1	E2	E3	
Baek [22]	2023	*	*	*	*	*	*	*	*	*	9
Wang [23]	2023	*	*	*	*	*	*	*	*	*	9
Wang [24]	2023	*	*	*	*	*	*	*	*	-	8
Zhou [13]	2021	*	*	*	*	*	*	*	*	*	9
Woo [26]	2020	*	*	*	*	*	*	*	*	*	9
Yi [27]	2019	*	*	*	*	*	-	*	*	*	8
Rigby [1]	2019	*	*	*	*	*	-	*	*	*	8
Li [28]	2017	*	*	*	*	*	-	*	*	*	8
Matsui [<mark>30</mark>]	2016	*	*	*	*	*	-	*	*	*	8

 \star : The scale uses a star symbol (\star) to represent points, and each star represents one point

S selection, C comparability, E exposure. S1 representativeness of the exposed cohort, S2 selection of the nonexposed cohort, S3 ascertainment of exposure, S4 demonstration that outcome of interest was not present at start of study. C1 comparability of controls for the most important factor, C2 comparability of controls for a second important factor. E1 assessment of outcome, E2 was follow-up long enough for outcomes to occur, E3 adequacy of follow-up of cohorts

a)	Experin			ntrol	Cot-1		Mean Difference	Mean Difference
Study or Subgroup							IV, Fixed, 95% Cl Year	IV, Fixed, 95% Cl
Wang(1) 2023		.2 32			31		1.10 [-0.90, 3.10] 2023	
Hou 2022 Yi 2019		5.5 36 1.2 35			34 30		8.40 [5.35, 11.45] 2022	
11 2019	07.7 4	.2 35	86.5	0.4	30	20.0%	1.20 [-1.48, 3.88] 2019	-
Total (95% CI)		103			95	100.0%	2.71 [1.29, 4.13]	•
Heterogeneity: Chi ² =	= 17.11. df :	= 2 (P = 0	.0002);	$1^2 = 88$				
Test for overall effect								–İ0 –5 Ó Ś IÓ Favours [experimental] Favours [control]
(b)	Experim	ental	Co	ntrol			Mean Difference	Mean Difference
Study or Subgroup	Mean S	D Total	Mean	SD 1	Total	Weight	IV, Random, 95% Cl Year	IV, Random, 95% CI
Wang② 2023	83.45 7.0	7 49	79.74	7.35	50	29.1%	3.71 [0.87, 6.55] 2023	_
Wang(1) 2023	80.3 3.	.8 32	79.5	4	31	31.1%	0.80 [-1.13, 2.73] 2023	- +
Hou 2022	84.3 8		75.3	7.5	34	26.5%	9.00 [5.18, 12.82] 2022	
Woo 2020	87.2 11.		73.5		26		13.70 [4.26, 23.14] 2020	
Yeo 2016	89.7 2.	.1 25	91.3	2.2	23	0.0%	-1.60 [-2.82, -0.38] 2016	
Total (05% CI)		143			141	100.0%	5 54 [1 08 0 00]	
Total (95% CI)	15 CF. Chi		46 2 (D 0 (5.54 [1.08, 9.99]	
Heterogeneity: Tau ² =			df = 3 (P = 0.0	JOO2);	$1^{2} = 85\%$		-10 -5 0 5 10
Test for overall effect:	Z = 2.44 (P	= 0.01)						Favours [experimental] Favours [control]
(a)								
(c)	Experim			ntrol			Mean Difference	Mean Difference
Study or Subgroup	Mean S	D Total	Mean	SD ⁻	Total	Weight	IV, Random, 95% CI Year	IV, Random, 95% Cl
Wang② 2023	87.24 4.9	96 49	86.7	5.3	50	22.0%	0.54 [-1.48, 2.56] 2023	
Wang(1) 2023	85 3	.9 32	84.3	4.4	31	21.3%	0.70 [-1.36, 2.76] 2023	
Hou 2022	88.9 8	.3 36	85.9	8.4	34	5.9%	3.00 [-0.91, 6.91] 2022	
Woo 2020	94.2	10 26	70.9	33.1	26		Not estimable 2020	
Yeo 2016	90.3 2	.4 25	89.2	2.3	23	50.8%	1.10 [-0.23, 2.43] 2016	
Total (95% CI)		142				100.0%	1.00 [0.05, 1.95]	
Heterogeneity: Tau ² =	= 0.00: Chi ²	= 1.31, d	f = 3 (P)	= 0.73	$1^{12} = 1^{12}$	0%		-1 -0.5 0 0.5 1
Test for overall effect		P = 0.04)			<i>)</i> , ·			
Test for overall effect		P = 0.04)			,, .			Favours [experimental] Favours [control]
Test for overall effect			Co	ntrol	,, .		Mean Difference	
Test for overall effect	: Z = 2.07 (F Experim			ntrol		Weight	Mean Difference IV, Fixed, 95% Cl Year	Favours [experimental] Favours [control]
Test for overall effect	: Z = 2.07 (F Experim	ental D Total		ntrol				Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) Study or Subgroup	Z = 2.07 (F Experim Mean S	ental D Total .1 32	Mean	ntrol SD	Total	Weight 8.5%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) Study or Subgroup Wang 0 2023 Baek 2023	Experim Mean S 91.9 5	ental D Total .1 32 .1 31	Mean 91.6	ntrol SD 7.1 5.8	Total 31	<u>Weight</u> 8.5% 7.9%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) <u>Study or Subgroup</u> Wang① 2023	Experim Mean S 91.9 5 92.7 7	ental D Total .1 32 .1 31 .1 49	Mean 91.6 95	ntrol SD 7.1 5.8	Total 31 34	<u>Weight</u> 8.5% 7.9%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023 -0.04 [-1.23, 1.15] 2023	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) <u>Study or Subgroup</u> Wang① 2023 Baek 2023 Wang② 2023	Experim Mean S 91.9 5 92.7 7 93.18 3	ental D Total .1 32 .1 31 .1 49 .7 36	Mean 91.6 95 93.22 94.4	ntrol SD 7.1 5.8 2.92 9	Total 31 34 50	Weight 8.5% 7.9% 56.3% 4.6%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023 -0.04 [-1.23, 1.15] 2023 0.30 [-3.85, 4.45] 2022	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) <u>Study or Subgroup</u> Wang 0 2023 Baek 2023 Wang 2 2023 Hou 2022	Experim Mean S 91.9 5 92.7 7 93.18 3 94.7 8 91.71 5.4	ental D Total .1 32 .1 31 .1 49 .7 36	Mean 91.6 93.22 94.4 90.67	ntrol SD 7.1 5.8 2.92 9	Total 31 34 50 34	Weight 8.5% 7.9% 56.3%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023 -0.04 [-1.23, 1.15] 2023 0.30 [-3.85, 4.45] 2022 1.04 [-1.61, 3.69] 2021	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) Study or Subgroup Wang① 2023 Baek 2023 Wang② 2023 Hou 2022 Zhou 2021	Experim Mean S 91.9 5 92.7 7 93.18 3 94.7 8 91.71 5.4 93.4 5	ental D Total .1 32 .1 31 .1 49 .7 36 46 31	Mean 91.6 93.22 94.4 90.67	ntrol SD 7.1 5.8 2.92 9 5.59	Total 31 34 50 34 36	Weight 8.5% 7.9% 56.3% 4.6% 11.3%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023 -0.04 [-1.23, 1.15] 2023 0.30 [-3.85, 4.45] 2022	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) <u>Study or Subgroup</u> Wang D 2023 Baek 2023 Wang 2023 Hou 2022 Zhou 2021 Yi 2019 Li 2017	Experim Mean S 91.9 5 92.7 7 93.18 3 94.7 8 91.71 5.4 93.4 5	ental D Total 1 32 1 31 1 49 7 36 6 31 7 35 .9 23	Mean 91.6 95 93.22 94.4 90.67 91.8	ntrol SD 7.1 5.8 2.92 9 5.59 7.3	Total 31 34 50 34 36 30 37	Weight 8.5% 7.9% 56.3% 4.6% 11.3% 7.6% 3.8%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023 0.04 [-1.23, 1.15] 2023 0.30 [-3.85, 4.45] 2022 1.04 [-1.61, 3.69] 2021 1.60 [-1.62, 4.82] 2019 0.90 [-3.67, 5.47] 2017	Favours [experimental] Favours [control] Mean Difference
Test for overall effect (d) Study or Subgroup Wang① 2023 Baek 2023 Wang② 2023 Hou 2022 Zhou 2021 Yi 2019 Li 2017 Total (95% CI)	Experim Mean S 91.9 5 92.7 7 93.18 3 94.7 8 91.71 5.4 93.4 5 93.3 8	ental D Total 1 32 1 31 1 49 7 36 6 31 7 35 9 23 237	Mean 91.6 95 93.22 94.4 90.67 91.8 92.4	ntrol SD - 7.1 5.8 2.92 9 5.59 7.3 8.6	Total 31 34 50 34 36 30 37	Weight 8.5% 7.9% 56.3% 4.6% 11.3% 7.6% 3.8%	IV, Fixed, 95% CI Year 0.30 [-2.76, 3.36] 2023 -2.30 [-5.47, 0.87] 2023 -0.04 [-1.23, 1.15] 2022 0.30 [-3.85, 4.45] 2022 1.04 [-1.61, 3.69] 2021 1.60 [-1.62, 4.82] 2019	Favours [experimental] Favours [control] Mean Difference
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Fig. 3 Forest plot of comparison of functional outcome. **a** 3 months postoperative AOFAS score. **b** 6 months postoperative AOFAS score. **c** 12 months postoperative AOFAS score. **d** 2 years postoperative AOFAS score. **e** 6 months postoperative K–P score. **f** 12 months postoperative K–P score. **g** 2 years postoperative K–P score. **h** Perioperative VAS score. **i** 6 months postoperative VAS score. **j** 12 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **k** 24 months postoperative VAS score. **i** 6 months postoperative VAS score. **i** 7 months postoperative VAS score.

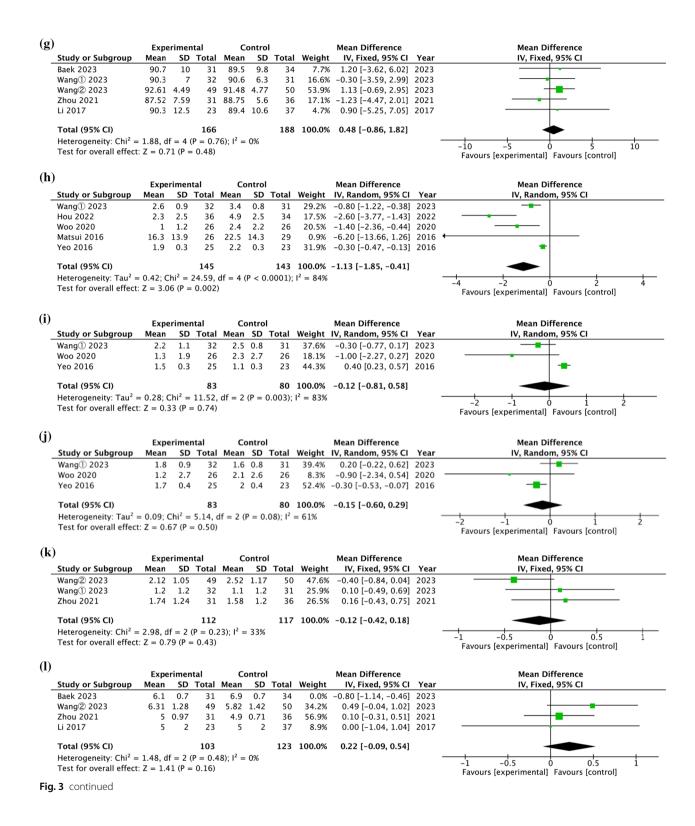


Fig. 3f demonstrated a significant difference between two surgical techniques (WMD=1.57, 95% CI=[0.49, 2.64], P=0.004), with low heterogeneity (P=0.15, I²=47%).

Five studies evaluated the postoperative 2-year K–P score of CLAI treated with open and arthroscopic Bro-strom-Gould surgery [13, 23, 24, 28, 32]. The pooled

results in Fig. 3g demonstrated no significant difference between two surgical techniques (WMD = 0.48, 95% CI = [-0.86, 1.82], P = 0.48), with no heterogeneity (P = 0.76, $I^2 = 0\%$).

VAS pain score

Five studies evaluated the perioperative VAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 25, 29-31]. The pooled results in Fig. 3h demonstrated a significant difference between two surgical techniques (WMD = -1.13, 95% CI = [-1.85, -0.41], P = 0.002), with high heterogeneity (P < 0.0001, $I^2 = 84\%$). Three studies evaluated the 6-month VAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 29, 31]. The pooled results in Fig. 3i demonstrated no significant difference between two surgical techniques (WMD = -0.12, 95% CI = [-0.81, 0.58], P = 0.74), with high heterogeneity (P < 0.003, $I^2 = 83\%$). Three studies evaluated the 1-year VAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 29, 31]. The pooled results in Fig. 3j demonstrated no significant difference between two surgical techniques (WMD = -0.15, 95% CI = [-0.60, 0.29], P = 0.50), with high heterogeneity (P < 0.08, $I^2 = 61\%$).

Three studies evaluated the 2-year VAS score of CLAI treated with open and arthroscopic Brostrom-Gould surgery [13, 23, 24]. The pooled results in Fig. 3k demonstrated no significant difference between two surgical techniques (WMD = -0.12, 95% CI = [-0.42, 0.18], P = 0.43), with low heterogeneity (P = 0.23, $I^2 = 33\%$).

Tegner

Three studies evaluated the Tegner scores at final follow-up [13, 24, 28]. The pooled results in Fig. 3L demonstrated no significant difference in the postoperative 2-year VAS score between two surgical techniques (WMD=0.22, 95% CI=[-0.09, 0.54], P=0.16), with no heterogeneity (P=0.48, $I^2=0\%$).

Radiological outcome

Anterior talar translation Five studies compared the postoperative anterior talar translation [23, 24, 27, 29, 30, 32]. A pooled analysis of the data in Fig. 4a found no significant difference between the two fixation approaches (WMD=-0.12 mm, 95% CI=[-0.30, 0.06], P=0.21), with no heterogeneity (P=0.98, $I^2=0\%$).

Talar tilt

Five studies compared the postoperative talar tilt [23, 27, 29, 30, 32]. A pooled analysis of the data in Fig. 4b found no significant difference between the two fixation approaches (WMD=-0.07 mm, 95% CI=[-0.63, 0.49], P=0.80), with high heterogeneity (P=0.01, $l^2=70\%$).

Time efficiency

Four studies compared the time to return to weightbearing [23, 25, 27, 30]. A pooled analysis of the data in Fig. 5a found a significant difference between two surgical techniques (WMD=-1.33 weeks, 95% CI=[-1.91, -0.76], P < 0.00001), with low heterogeneity (P = 0.17, $I^2 = 40\%$).

Two studies evaluated the time to return to sports of CLAI treated with open and arthroscopic Brostrom-Gould surgery [23, 30]. The pooled results in Fig. 5b

(a)	Expe	erimen	tal	c	ontrol			Mean Difference		Mean Difference
Study or Subgroup	Mean			Mean			Weight	IV, Fixed, 95% CI	Year	IV, Fixed, 95% Cl
Baek 2023	4.6	1.8	31	4.5	1.8	34	4.3%	0.10 [-0.78, 0.98]	2023	
Wang① 2023	5.1	1.3	32	6.3	1.9	31	0.0%	-1.20 [-2.01, -0.39]	2023	
Wang② 2023	5.33	1.4	49	5.54	1.54	50	9.9%	-0.21 [-0.79, 0.37]	2023	
Yi 2019	3.2	0.4	35	3.3	0.5	30	66.9%	-0.10 [-0.32, 0.12]	2019	
Matsui 2016	2.7	0.76	26	2.9	0.99	29	15.4%	-0.20 [-0.66, 0.26]	2016	
Yeo 2016	6.7	1.3	25	6.8	2.06	23	3.4%	-0.10 [-1.08, 0.88]	2016	
Total (95% CI)			166			166	100.0%	-0.12 [-0.30, 0.06]		-
Heterogeneity: Chi ² = Test for overall effect				98); 1* =	: 0%					
		(.	••==,							Favours [experimental] Favours [control]
(h)										
(b)	Expe	erimen	tal	C	ontrol			Mean Difference		Mean Difference
(b) Study or Subgroup	Expe Mean	erimen SD		C Mean		Total	Weight	Mean Difference IV, Random, 95% CI	Year	Mean Difference IV, Random, 95% Cl
	-	SD					Weight 7.7%			
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	7.7%	IV, Random, 95% CI	2023	
Study or Subgroup Baek 2023	Mean 5.2	SD 4.1	Total 31	Mean 5.4	SD 3.3	Total 34	7.7%	IV, Random, 95% CI -0.20 [-2.02, 1.62]	2023 2023	
Study or Subgroup Baek 2023 Wang① 2023	Mean 5.2 2.1	SD 4.1 1.5 0.8	Total 31 32	Mean 5.4 4.4 3.1	SD 3.3 3.7	Total 34 31	7.7% 11.5%	IV, Random, 95% Cl -0.20 [-2.02, 1.62] -2.30 [-3.70, -0.90]	2023 2023 2019	
Study or Subgroup Baek 2023 Wang① 2023 Yi 2019	Mean 5.2 2.1 3.3	SD 4.1 1.5 0.8 1.51	Total 31 32 35	Mean 5.4 4.4 3.1 3.8	SD 3.3 3.7 0.4	Total 34 31 30	7.7% 11.5% 36.0%	IV, Random, 95% CI -0.20 [-2.02, 1.62] -2.30 [-3.70, -0.90] 0.20 [-0.10, 0.50]	2023 2023 2019 2016	
Study or Subgroup Baek 2023 Wang① 2023 Yi 2019 Yeo 2016	Mean 5.2 2.1 3.3 3.9	SD 4.1 1.5 0.8 1.51	Total 31 32 35 25	Mean 5.4 4.4 3.1 3.8	SD 3.3 3.7 0.4 3.61	Total 34 31 30 23 29	7.7% 11.5% 36.0% 9.5%	IV, Random, 95% CI -0.20 [-2.02, 1.62] -2.30 [-3.70, -0.90] 0.20 [-0.10, 0.50] 0.10 [-1.49, 1.69] 0.35 [0.02, 0.68]	2023 2023 2019 2016 2016	
Study or Subgroup Baek 2023 Wang① 2023 Yi 2019 Yeo 2016 Matsui 2016	Mean 5.2 2.1 3.3 3.9 3.15	SD 4.1 1.5 0.8 1.51 0.5	Total 31 32 35 25 26 149	Mean 5.4 4.4 3.1 3.8 2.8	SD 3.3 3.7 0.4 3.61 0.74	Total 34 31 23 29 147	7.7% 11.5% 36.0% 9.5% 35.3% 100.0%	IV, Random, 95% CI -0.20 [-2.02, 1.62] -2.30 [-3.70, -0.90] 0.20 [-0.10, 0.50] 0.10 [-1.49, 1.69] 0.35 [0.02, 0.68]	2023 2023 2019 2016 2016	IV, Random, 95% CI
Study or Subgroup Baek 2023 Wang① 2023 Yi 2019 Yeo 2016 Matsui 2016 Total (95% CI)	Mean 5.2 2.1 3.3 3.9 3.15 = 0.20; 0	SD 4.1 1.5 0.8 1.51 0.5	Total 31 32 35 25 26 149 13.20,	Mean 5.4 4.4 3.1 3.8 2.8	SD 3.3 3.7 0.4 3.61 0.74	Total 34 31 23 29 147	7.7% 11.5% 36.0% 9.5% 35.3% 100.0%	IV, Random, 95% CI -0.20 [-2.02, 1.62] -2.30 [-3.70, -0.90] 0.20 [-0.10, 0.50] 0.10 [-1.49, 1.69] 0.35 [0.02, 0.68]	2023 2023 2019 2016 2016	

Fig. 4 Forest plot of comparison of radiological outcome. a Talar anterior translation. b Talar tilt

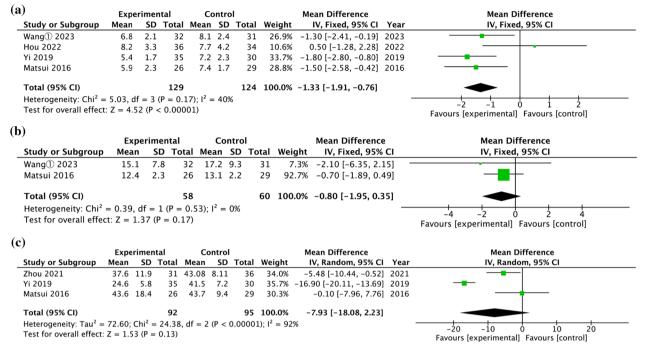


Fig. 5 Forest plot of comparison of time efficiency. a Time to return to weightbearing. b Time to return to sports. c Operative time

demonstrated no significant difference between two surgical techniques (WMD = -0.80 weeks, 95% CI = [-1.95, 0.35], P=0.17), with no heterogeneity (P=0.53, I²=0%).

Three studies evaluated the operative time of CLAI treated with open and arthroscopic Brostrom-Gould surgery [13, 27, 30]. The pooled results in Fig. 5c demonstrated no significant difference between two surgical techniques (WMD = -7.93 min, 95% CI = [-18.08, 2.23], P = 0.13), with high heterogeneity (P < 0.00001, I² = 92%).

Complications

Total complications All eleven studies reported total complications [1, 13, 23–25, 27–32]. The pooled analysis in Fig. 6a found no significant difference in total complications between the two fixation approaches (OR=0.96, 95% CI=[0.57, 1.60], P=0.86), with no heterogeneity (P=0.92, I²=0%).

Nerve complications All eleven studies reported nerve complications [1, 13, 23–25, 27–32]. The pooled analysis in Fig. 6b found no significant difference in nerve complications between the two fixation approaches (OR=1.63, 95% CI=[0.73, 3.61], P=0.23), with no heterogeneity (P=0.89, I²=0%).

Discussion

The results of our study demonstrated comparable outcomes between the two fixation approaches in terms of talar tilt, anterior talar translation, final follow-up AOFAS, K–P, VAS, and Tegner scores, complication rate, time to return to sports, and operation time. However, significant differences were observed in AOFAS, K–P, and VAS scores within 12 months postoperatively. Additionally, there were significant differences between the two surgical approaches regarding early weight-bearing. Arthroscopic repair allowed early postoperative activity.

Two previous studies have compared arthroscopic and open Broström-Gould techniques [10, 33]. However, the earlier study included only four studies, and the other included eight studies with low homogeneity and significant heterogeneity in their results. With an increasing number of recent comparative studies on these two techniques, we included more relevant studies. This improves the reliability of our findings.

Radiological outcome

Our results demonstrate no significant difference between the two surgical approaches in postoperative talar tilt and anterior talar translation. Arthroscopic modified Brostrom operation demonstrated favorable outcomes comparable to open repair, as assessed by biomechanical activity and clinical measures [34–36]. In a study conducted by Kim et al. involving 28 ankles, the final follow-up AOFAS score showed a significant increase compared to the preoperative score, and there was a notable improvement in the anterior drawer test score [37]. In a study conducted by Nery et al. [2]

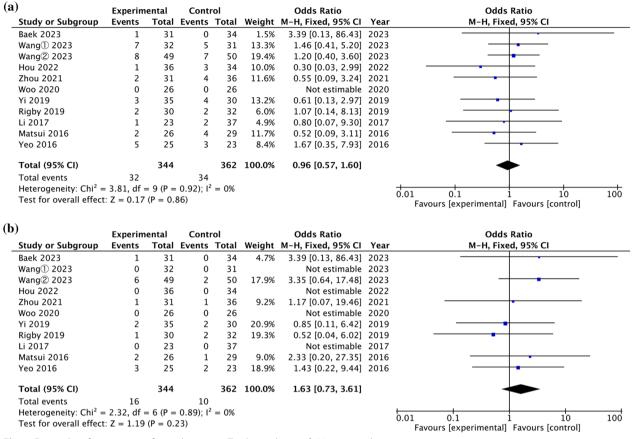


Fig. 6 Forest plot of comparison of complications. a Total complication b Nerve complication

involving 38 patients, it was found that the average AOFAS score at the final follow-up assessment was 90, and there were no significant differences in radiographic findings between the injured side and the contralateral side. In a biomechanical study by Lee et al. [36], Eleven matched pairs of human cadaver specimens were utilized to compare the outcomes of arthroscopic Broström-Gould operation using a suture anchor and open modified Brostrom surgery. The study evaluated parameters such as degrees to failure, torque to failure, and stiffness. The results showed that the two surgical approaches had similar parameters with no significant differences. Giza et al. [35] also reported similar findings, which are consistent with Lee et al. These two studies demonstrated that the arthroscopic and open approaches to Broström-Gould operation resulted in comparable postoperative strength and stiffness.

Functional outcomes scores

The previous meta-analysis compared the changes in functional scores over time, including AOFAS, K–P, and VAS scores. However, the analysis was restricted to a one-year follow-up period [33]. In our study, we

compared the changes over two years. The results indicated that the arthroscopic group outperformed the open group regarding AOFAS, K–P, and VAS scores within one year of follow-up. However, after a two-year followup, our results showed no significant difference in scores between the two fixation approaches.

The K-P score was suggested in 1991 to assess ankle function, explicitly focusing on ankle instability. Despite its widespread use, the validity of the K-P score has not been subjected to the same rigorous scrutiny as the AOFAS score [38]. As one of the most commonly used functional scores in clinical practice, the AOFAS score still requires additional validation studies to determine the reliability and clinical significance, especially in the case of minimal clinically significant differences. In their study, Nery et al. [2] examined 28 patients who received arthroscopic Brostrom-Gould repair for CLAI. The mean follow-up period was 9.8 years, and the average AOFAS score at the last follow-up was 90. Almost all patients (94.7%) achieved excellent and good postoperative AOFAS scores. Acevedo and Mangone's study encompassed 93 patients who underwent arthroscopic surgery and observed a notable enhancement

in the Karlsson-Peterson score. The score significantly increased from an average preoperative value of 28.3 to a postoperative average of 90.2. Regarding patient satisfaction, 69 out of 73 individuals reported being content with the results, while 4 expressed dissatisfaction [39]. The arthroscopic approach resulted in significantly less early postoperative pain, primarily attributed to its reduced invasiveness and minimal joint capsule dissection compared to the open group [25]. This is consistent with our results. It is widely acknowledged that the open Broström-Gould surgery, a frequently employed procedure for treating CLAI, showed favorable outcomes in the medium term. After a 9-year follow-up, Maffulli et al. [40] reported a significant enhancement in AOFAS scores, increasing them from 51 to 90 points, in patients who underwent open Broström-Gould surgery. Nery et al. [2] utilized the arthroscopic-assisted Broström-Gould procedure to treat CLAI. At a mean follow-up of 9.8 years, 94.7% of patients had postoperative AOFAS scores rated excellent and good. Buerer et al. [41] reported a high satisfaction rate in their study of 41 patients who underwent open modified Broström repair, with an average AOFAS score of 89 at the final follow-up. Molloy et al. [42] investigated the outcomes of open Broström-Gould repair in 21 patients with persistent CLAI. The study showed a significant improvement in AOFAS scores, with the preoperative scores of 53 increasing to 89 after a 25-month follow-up period. Furthermore, several studies have demonstrated that the arthroscopic approach yields favorable treatment outcomes for CLAI [14, 43]. These studies only show the functional scores of open surgery at the final follow-up and do not indicate the postoperative changes over time. Our results showed that arthroscopic repair was superior to open surgical procedure regarding early postoperative functional scores. The superior functional scores in the arthroscopic group can be attributed to the minimal soft tissue dissection. Secondly, the arthroscopic approach minimizes the risk of injuring blood vessels surrounding the ATFL and promotes the repaired ATFL's vascularization. Conversely, the open group necessitated a more prolonged procedure due to the greater surgical trauma. However, we did not determine whether the differences in functional outcomes at one year exceeded the minimal clinically important difference, or if these differences were clinically relevant. Further research is needed to investigate these aspects.

Complications

Our findings indicate that there were no significant differences between the two surgical approaches in terms of overall complications and nerve injuries. The literature reports general complication rates ranging from 0 to 35% for arthroscopic lateral ankle ligament repair, while the open technique shows variability with rates between 0 and 29.6% [11]. The complications reported encompass injuries to the superficial peroneal nerve, wound infections, delayed wound healing, deep vein thrombosis, and the occurrence of residual ankle instability. In a comprehensive review comprising six studies, Wang et al. [44] provided an overview of the complication rates associated with arthroscopic repair of lateral ankle instability, which ranged from 0 to 41.9%. Based on previous research findings [33, 45, 46], there is a higher incidence of superficial peroneal nerve complications in arthroscopic surgery. In addition, several studies have reported that the incisions used in open surgery are close to the superficial peroneal nerve, making it vulnerable to injury [28, 47]. However, our study aligns with a previous meta-analysis that reported a similar incidence of nerve injury between the two surgical techniques [33]. The literature has previously documented safety zones in ankle surgeries, showing an average 5.1 cm (3.9-6.4 cm) internervous safe zone between the superficial peroneal nerve and the sural nerve, and an average 4.3 cm (3.7-6.4 cm) inter-tendon safe zone between the peroneus brevis and the peroneus tertius tendon [39]. During arthroscopic surgery, structures in this region were relatively safe from damage caused by portals or suture passages [48]. Our results revealed a higher incidence of nerve injury in the arthroscopic repair group at 4.6%, compared to 2.8% in the open group. However, there was no statistically significant difference between the two surgical approaches. Therefore, nerve injury is not a disadvantage specific to arthroscopic surgery. Using arthroscopic techniques for repair does not result in a higher risk of nerve injury.

Time efficiency

Additionally, we compared the early postoperative activity time between the two repair techniques and found that arthroscopic repair showed significant advantages over the open group. However, our results indicate no significant difference in the recovery time for regaining complete activity levels between the two fixation approaches. Recently, Hou et al. [25] reported that six months after surgery, the arthroscopic group exhibited a shorter recovery period, higher return rates to athletic activities, and notable improvements in clinical outcomes, muscular strength, and posture control. This may be why some studies show faster recovery from arthroscopic surgery [30, 31]. Our results indicate no significant difference in operation time between the two surgical approaches. However, the result needs to be carefully considered. Experienced surgeons may find that arthroscopic techniques can reduce surgical time due to the absence of skin incision and suturing requirements. Zhou et al. [13] observed that the surgical duration in

the first 7 cases was significantly longer compared to the subsequent 24 cases. However, they found that the surgeries in the latter 24 cases could be completed within 45 min. Matsui et al. [30] reported the surgical duration of arthroscopic procedures in their study. They observed that the initial 6 cases had a longer average surgical time of 57.2 min (range 40–95), whereas, in the subsequent 13 patients, the surgical time significantly reduced to an average of 29.6 min (range 22–37). There is a learning curve associated with arthroscopic techniques, and surgeons performing this procedure require adequate training in advance.

Our meta-analysis also had some limitations. First, our study only included two RCTs and did not include more randomized controlled studies of higher methodological quality. This study suggests the need for conducting randomized controlled trials in a multicenter setting to obtain more definitive conclusions. Second, our study did not perform a subgroup analysis on patient weight, which may have influenced the results. Third, our meta-analysis identified the lack of standardization among studies as a significant confounding factor. Fourth, the meta-analysis included studies with varying length follow-up periods, which introduces a potential source of heterogeneity. These factors may impact the reliability and stability of the conclusions drawn from our meta-analysis. Fifth, there may be technical heterogeneity among the included studies, which could impact our results.

Conclusion

Our findings support that arthroscopic repair yields comparable outcomes to open surgery. Consequently, we advocate for adopting arthroscopic repair as a preferred alternative to the conventional open Broström-Gould procedure for treating chronic lateral ankle instability.

Abbreviations

- CLAI Chronic lateral ankle instability
- ATFL Anterior talofibular ligament
- RCT Randomised controlled trials
- NOS Newcastle-Ottawa scale
- OR Odds ratios
- CI Confidence interval
- WMD Weighted mean difference

Acknowledgements

We appreciate all co-authors for their contributions to this study and the writing of this manuscript.

Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by BZ and QS. The first draft of the manuscript was written by BZ and QS, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding

Supported by Beijing Key Clinical Specialty Project.

Availability of data and materials

All data generated or analysed during this study are included in this article.

Declarations

Ethics approval and consent to participate

Ethics approval was not required for this systematic review.

Informed consent

As this was a systematic review, data from individual participants was not obtained and will not be published.

Competing interests

The author declare that they have no potential competing interests.

Received: 28 July 2023 Accepted: 15 October 2023 Published online: 14 November 2023

References

- 1. Rigby RB, Cottom JM. A comparison of the "all-inside" arthroscopic Broström procedure with the traditional open modified Broström-Gould technique: a review of 62 patients. Foot Ankle Surg. 2019;25:31–6.
- 2. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N. Arthroscopic-assisted Broström-Gould for chronic ankle instability: a long-term follow-up. Am J Sports Med. 2011;39:2381–8.
- Van Rijn RM, Van Os AG, Bernsen RMD, Luijsterburg PA, Koes BW, Bierma-Zeinstra SMA. What is the clinical course of acute ankle sprains? A systematic literature review. Am J Med. 2008;121:324-331.e7.
- Gould N, Seligson D, Gassman J. Early and late repair of lateral ligament of the ankle. Foot Ankle. 1980;1:84–9.
- Ahn H, Lee K-B. Comparison of the modified Broström procedure for chronic lateral ankle instability with and without subfibular ossicle. Am J Sports Med. 2016;44:3158–64.
- Lee KT, Park YU, Kim JS, Kim JB, Kim KC, Kang SK. Long-term results after modified brostrom procedure without calcaneo-fibular ligament reconstruction. Foot Ankle Int. 2011;32:153–7.
- Hong CC, Calder J. Ability to return to sports after early lateral ligament repair of the ankle in 147 elite athletes. Knee Surg Sports Traumatol Arthrosc. 2022. https://doi.org/10.1007/s00167-022-07270-2.
- Hu C-Y, Lee K-B, Song E-K, Kim M-S, Park K-S. Comparison of bone tunnel and suture anchor techniques in the modified Broström procedure for chronic lateral ankle instability. Am J Sports Med. 2013;41:1877–84.
- Xu H-X, Choi M-S, Kim M-S, Park K-S, Lee K-B. Gender differences in outcome after modified Broström procedure for chronic lateral ankle instability. Foot Ankle Int. 2016;37:64–9.
- Brown AJ, Shimozono Y, Hurley ET, Kennedy JG. Arthroscopic versus open repair of lateral ankle ligament for chronic lateral ankle instability: a metaanalysis. Knee Surg Sports Traumatol Arthrosc. 2020;28:1611–8.
- Guelfi M, Zamperetti M, Pantalone A, Usuelli FG, Salini V, Oliva XM. Open and arthroscopic lateral ligament repair for treatment of chronic ankle instability: a systematic review. Foot Ankle Surg. 2018;24:11–8.
- 12. Hintermann B, Boss A, Schäfer D. Arthroscopic findings in patients with chronic ankle instability. Am J Sports Med. 2002;30:402–9.
- Zhou Y-F, Zhang Z-Z, Zhang H-Z, Li W-P, Shen H-Y, Song B. All-inside arthroscopic modified broström technique to repair anterior talofibular ligament provides a similar outcome compared with open Broström-Gould procedure. Arthrosc J Arthrosc Relat Surg. 2021;37:268–79.
- Feng S-M, Maffulli N, Ma C, Oliva F. All-inside arthroscopic modified Broström-Gould procedure for chronic lateral ankle instability with and without anterior talofibular ligament remnant repair produced similar functional results. Knee Surg Sports Traumatol Arthrosc. 2021;29:2453–61.
- Baumbach SF, Herterich V, Damblemont A, Hieber F, Böcker W, Polzer H. Open reduction and internal fixation of the posterior malleolus fragment frequently restores syndesmotic stability. Injury. 2019;50:564–70.
- Aicale R, Maffulli N. Chronic lateral ankle instability: topical review. Foot Ankle Int. 2020;41:1571–81.

- Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4:1.
- Schiavo JH. PROSPERO: an international register of systematic review protocols. Med Ref Serv Q. 2019;38:171–80.
- Higgins JPT, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, et al. The cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343:d5928–d5928.
- Stang A. Critical evaluation of the Newcastle–Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol. 2010;25:603–5.
- 21. Singotani RG, Karapinar F, Brouwers C, Wagner C, de Bruijne MC. Correction to: towards a patient journey perspective on causes of unplanned readmissions using a classification framework: results of a systematic review with narrative synthesis. BMC Med Res Methodol. 2019;19:214.
- 22. Baek JH, Kim JH, Jeong BO. Arthroscopic Broström-Gould repair has comparable radiological and clinical outcomes compared to traditional open Broström-Gould repair in high-demand patients. Knee Surg Sports Traumatol Arthrosc. 2023;31:2208–15.
- 23. Wang A-H, Su T, Jiang Y-F, Zhu Y-C, Jiao C, Hu Y-L, et al. Arthroscopic modified Broström procedure achieved similar favorable short term outcomes to open procedure for chronic lateral ankle instability cases with generalized joint laxity. Knee Surg Sports Traumatol Arthrosc. 2023.
- Wang J, Tang Z, Sun H, Lv J, Jiang H, Yue Y. Arthroscopic versus open Broström-Gould for repairing anterior talofibular ligament: mid-term outcomes comparison. Front Surg. 2023;10:1181493.
- Hou Z-C, Su T, Ao Y-F, Hu Y-L, Jiao C, Guo Q-W, et al. Arthroscopic modified Broström procedure achieves faster return to sports than open procedure for chronic ankle instability. Knee Surg Sports Traumatol Arthrosc. 2022;30:3570–8.
- Woo BJ, Lai MC, Koo K. Response to "letter regarding: arthroscopic versus open Broström-Gould repair for chronic ankle instability." Foot Ankle Int. 2020;41:656–7.
- 27. Yi G, Fu S, Yang J, Wang G, Liu Y, Guo X, et al. A comparative study of allarthroscopic technique and modified open Broström technique in repair of anterior talofibular ligament with anchors. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi Zhongguo Xiufu Chongjian Waike Zazhi Chin J Reparative Reconstr Surg. 2019;33:1503–9.
- Li H, Hua Y, Li H, Ma K, Li S, Chen S. Activity level and function 2 years after anterior talofibular ligament repair: a comparison between arthroscopic repair and open repair procedures. Am J Sports Med. 2017;45:2044–51.
- Yeo ED, Lee K-T, Sung I-H, Lee SG, Lee YK. Comparison of all-inside arthroscopic and open techniques for the modified Broström procedure for ankle instability. Foot Ankle Int. 2016;37:1037–45.
- Matsui K, Takao M, Miyamoto W, Matsushita T. Early recovery after arthroscopic repair compared to open repair of the anterior talofibular ligament for lateral instability of the ankle. Arch Orthop Trauma Surg. 2016;136:93–100.
- Woo BJ, Lai MC, Koo K. Arthroscopic versus open Broström-Gould repair for chronic ankle instability. Foot Ankle Int. 2020;41:647–53.
- Beak JS, Kim YT, Lee SH. Predisposing factors for posttraumatic osteoarthritis after malleolus fracture fixation in patients younger than 50 years. Foot Amp Ankle Int. 2022;43:389–97.
- Attia AK, Taha T, Mahmoud K, Hunt KJ, Labib SA, d'Hooghe P. Outcomes of open versus arthroscopic Broström surgery for chronic lateral ankle instability: a systematic review and meta-analysis of comparative studies. Orthop J Sports Med. 2021;9:232596712110152.
- Drakos MC, Behrens SB, Paller D, Murphy C, DiGiovanni CW. Biomechanical comparison of an open versus arthroscopic approach for lateral ankle instability. Foot Ankle Int. 2014;35:809–15.
- Giza E, Shin EC, Wong SE, Acevedo JI, Mangone PG, Olson K, et al. Arthroscopic suture anchor repair of the lateral ligament ankle complex: a cadaveric study. Am J Sports Med. 2013;41:2567–72.
- Lee KT, Kim ES, Kim YH, Ryu JS, Rhyu IJ, Lee YK. All-inside arthroscopic modified Broström operation for chronic ankle instability: a biomechanical study. Knee Surg Sports Traumatol Arthrosc. 2016;24:1096–100.
- Kim ES, Lee KT, Park JS, Lee YK. Arthroscopic anterior talofibular ligament repair for chronic ankle instability with a suture anchor technique. Orthopedics. 2011. https://doi.org/10.3928/01477447-20110228-03.
- Kubo M, Yasui Y, Sasahara J, Miki S, Kawano H, Miyamoto W. Simultaneous ossicle resection and lateral ligament repair give excellent clinical

results with an early return to physical activity in pediatric and adolescent patients with chronic lateral ankle instability and os subfibulare. Knee Surg Sports Traumatol Arthrosc. 2020;28:298–304.

- Acevedo JI, Mangone P. Arthroscopic brostrom technique. Foot Ankle Int. 2015;36:465–73.
- Maffulli N, Del Buono A, Maffulli GD, Oliva F, Testa V, Capasso G, et al. Isolated anterior talofibular ligament Broström repair for chronic lateral ankle instability: 9-year follow-up. Am J Sports Med. 2013;41:858–64.
- Buerer Y, Winkler M, Burn A, Chopra S, Crevoisier X. Evaluation of a modified Broström-Gould procedure for treatment of chronic lateral ankle instability: a retrospective study with critical analysis of outcome scoring. Foot Ankle Surg. 2013;19:36–41.
- Molloy AP, Ajis A, Kazi H. The modified Broström-Gould procedure–early results using a newly described surgical technique. Foot Ankle Surg. 2014;20:224–8.
- 43. Allegra F, Boustany SE, Cerza F, Spiezia F, Maffulli N. Arthroscopic anterior talofibular ligament reconstructin in chronic ankle instability: two years results. Injury. 2020;51(Suppl 3):556-62.
- Wang J, Hua Y, Chen S, Li H, Zhang J, Li Y. Arthroscopic repair of lateral ankle ligament complex by suture anchor. Arthrosc J Arthrosc Relat Surg. 2014;30:766–73.
- Moorthy V, Sayampanathan AA, Yeo NEM, Tay KS. Clinical outcomes of open versus arthroscopic Broström procedure for lateral ankle instability: a meta-analysis. J Foot Ankle Surg. 2021;60:577–84.
- Vega J, Dalmau-Pastor M, Malagelada F, Fargues-Polo B, Peña F. Ankle arthroscopy: an update. J Bone Jt Surg. 2017;99:1395–407.
- De Leeuw PAJ, Golanó P, Sierevelt IN, Van Dijk CN. The course of the superficial peroneal nerve in relation to the ankle position: anatomical study with ankle arthroscopic implications. Knee Surg Sports Traumatol Arthrosc. 2010;18:612–7.
- Flores Santos F, Santos NR. Arthroscopic treatment of lateral ankle instability. Is there a safe zone? An anatomic study. Foot Ankle Surg. 2020;26:61–5.

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