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Minimally invasive surgical treatment for chronic ankle instability: a systematic review

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Abstract
Purpose The purpose of this study was to determine the evidence-based support for the treatment for chronic ankle instability (CAI) using minimally invasive surgery (MIS) techniques.
Methods A systematic comprehensive review of the literature was performed on 4 September 2015 using PubMed, EMBASE, Cochrane databases and Web of Science along with the two search concepts: lateral ligament of the ankle (patients) and minimally invasive surgical procedure (intervention). Articles of clinical study on MIS for CAI were included in this review and classified into four MIS categories (arthroscopic repair, non-arthroscopic minimally invasive repair, arthroscopic reconstruction and non-arthroscopic minimally invasive reconstruction) based on the adopted surgical procedure. Included articles were reviewed and assigned a classification according to the research method quality of evidence (Level I–V evidence). Analysis of these studies was then conducted to provide a grade of recommendation for each MIS category.
Results The systematic literature review generated 430 articles, and 33 articles met our inclusion criteria. The highest recommendation was Grade C (poor-quality evidence) to support the use of the arthroscopic repair, arthroscopic reconstruction and non-arthroscopic minimally invasive reconstruction. Insufficient evidence was currently available to make any recommendation (Grade I) for non-arthroscopic minimally invasive repair category.
Conclusions Despite recent increases in publications on MIS for the treatment for CAI, there was currently poor quality of evidence that was insufficient to allow a high grade of recommendation to support the use of the MIS. This paper should stimulate those surgeons performing higher quality studies in the form of prospective and preferably randomized comparative studies that will be necessary to allow better recommendations for the treatment for CAI

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with MIS. The present study showed thorough evidence-based recommendation for the clinical use of the MIS based on the comprehensive review of the literature.
Level of evidence Systematic review, Level IV.

Keywords Ankle lateral ligament · Minimally invasive surgery · Arthroscopy · Ankle instability · Systematic review

Abbreviations

ATFL	Anterior talofibular ligament
CFL	Calcaneofibular ligament
PTFL	Posterior talofibular ligament
CAI	Chronic ankle instability
MIS	Minimally invasive surgeries
AOFAS score	American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale score
IER	Inferior extensor retinaculum
BMI	Body mass index
VAS	Visual analog scale for pain
ADT	Anterior drawer test
TTA	Talar tilting angle
NA	Not applicable

Introduction

Ankle sprain is one of the most common sports-related injuries and involves the lateral ligament complex of the ankle [4, 13]. Within the three ligaments of the lateral ligament complex, 80 % of patients tear the anterior talofibular ligament (ATFL), while the other 20 % of patients tear the ATFL and calcaneofibular ligament (CFL). Rarely, the posterior talofibular ligament (PTFL) is involved [4]. An incidence of 10–30 % of patients will fail conservative treatment and result in chronic ankle instability (CAI) that may require surgical treatment [10, 18, 31, 36]. To date, numerous open surgical procedures for anatomical repair or reconstruction of ATFL and/or CFL provide good clinical results [8, 13, 36].

There has been a recent advent of published descriptions on minimally invasive surgeries (MIS) for CAI [1–3, 5–7, 9, 11, 12, 14–17, 19–26, 29, 30, 32–35, 37–39, 43, 44]. These MIS encompass two major categories: anatomical repair or reconstruction of the ATFL and/or CFL. Both categories embrace arthroscopic or non-arthroscopic minimally invasive techniques. Percutaneous techniques or mini-open techniques were included in non-arthroscopic minimally invasive approach. However, there was no study reviewed the literatures about all categories of MIS for CAI and showed the current best available evidence for these procedures. The purpose of this study was to determine the evidence-based support for the treatment for CAI using arthroscopic or non-arthroscopic minimally invasive surgery (MIS) techniques. The literatures included this study were classified into the following four main categories of the MIS approaches and reviewed based on their surgical procedure:

1. Arthroscopic repair
2. Non-arthroscopic minimally invasive repair
3. Arthroscopic reconstruction
4. Non-arthroscopic minimally invasive reconstruction

Materials and methods

All published and unpublished clinical studies with English translation were included. This systematic review excluded biomechanical studies, review articles and studies about non-repair or non-reconstruction MIS procedure such as tenodesis procedure. The reconstruction techniques were defined as the use of grafts to recreate the new connections between bones, the new ligaments. Conversely, the repair techniques were defined as reattachment or strengthening of torn or damaged ligaments. Comprehensive literature searches were conducted (4 September 2015) by use of PubMed, EMBASE, Cochrane databases and Web of Science, and thorough hand searching of references in narrative and systematic reviews. The search strategy used for PubMed, which was modified for other database, was as follows: using the search terms (((((((Minimally invasive surg*[tw]) OR Mini open[tw]) OR Percutaneous[tw]) OR Arthroscop*) OR ""Endoscopy" "[Mesh]) OR ""Arthroscopy" "[Mesh]) OR ""Minimally Invasive Surgical Procedures" "[Mesh])) AND ((((((((PTFL) OR CFL) OR ATFL) OR Talofibular[tw]) OR Calcaneofibular[tw]) OR Posterior talofibular[tw]) OR Anterior talofibular[tw]) OR ""Lateral Ligament, Ankle" "[Mesh]) with filters: English. The search terms included two concepts: lateral ligament of the ankle (patients) and minimally invasive surgical procedure (intervention).

All records found in the literature search were screened by titles and abstracts. Potentially relevant records were selected for full-text review. Each of the identified article was reviewed and assigned to one of the four MIS categories based on the adopted surgical approaches. Each article was then classified according to the research method quality of evidence into Level I to V by use of the level of evidence criteria described by Wright et al. [42]. Series with fewer than five patients or those who had poor data correction were classified as Level V evidence. Studies in which the retrospective or prospective nature was not apparent were classified as retrospective. After the assignment of the quality of evidence for each paper, analysis of all studies combined was then conducted to provide a grade of recommendation for each MIS category using four levels (A, B, C, or I) according to Wright et al. in 2005 [41].

Result

The systematic comprehensive literature searches of electronic databases and grey literature identified 430 non-duplicate records, which 47 articles were selected for full-text review and 33 of these studies [1–3, 5–7, 9, 11, 12, 14–17, 19–26, 29, 30, 32–35, 37–39, 43, 44] met the inclusion criteria (Fig. 1). Of the included studies, 21 studies [1–3, 5–7, 14–17, 19, 20, 22, 24–26, 28, 29, 35, 37, 38] were classified into arthroscopic repair category, six studies [11, 12, 23, 32–34] were classified into arthroscopic reconstruction category, no papers were classified into non-arthroscopic minimally invasive repair category and six papers [9, 21, 30, 39, 40, 43, 44] were classified into non-arthroscopic minimally invasive reconstruction category.

A summary of the grade of recommendations for or against the current accepted indications for each four minimally invasive surgical category is presented in Table 1. All the studies showed affirmative conclusion for using minimally invasive approach, therefore the recommendation for each category was for. However, poor-quality or insufficient evidence existed for the use of any minimally invasive approach. A summary of key articles describing the current techniques for each category was provided.

Arthroscopic repair

Twenty-one studies were published on arthroscopic repair [1–3, 5–7, 14–17, 19, 20, 22, 24–26, 28, 29, 35, 37, 38]. The first arthroscopic repair technique was reported in 1987 [14], and this area was the most published minimally invasive ankle stabilization technique in recent years. Suture anchor fixation of the ligaments was adopted in 12 papers [1, 2, 5, 6, 16, 17, 20, 22, 26, 28, 35, 37], thermal shrinkage in seven [3, 7, 15, 19, 25, 29, 38], and others included stapling [14] and bone tunnel [24] (Table 2). Kashuk et al. [17] reported the first arthroscopic repair using suture anchor in 1994, and the following 11 studies [1, 2, 5, 6, 16,

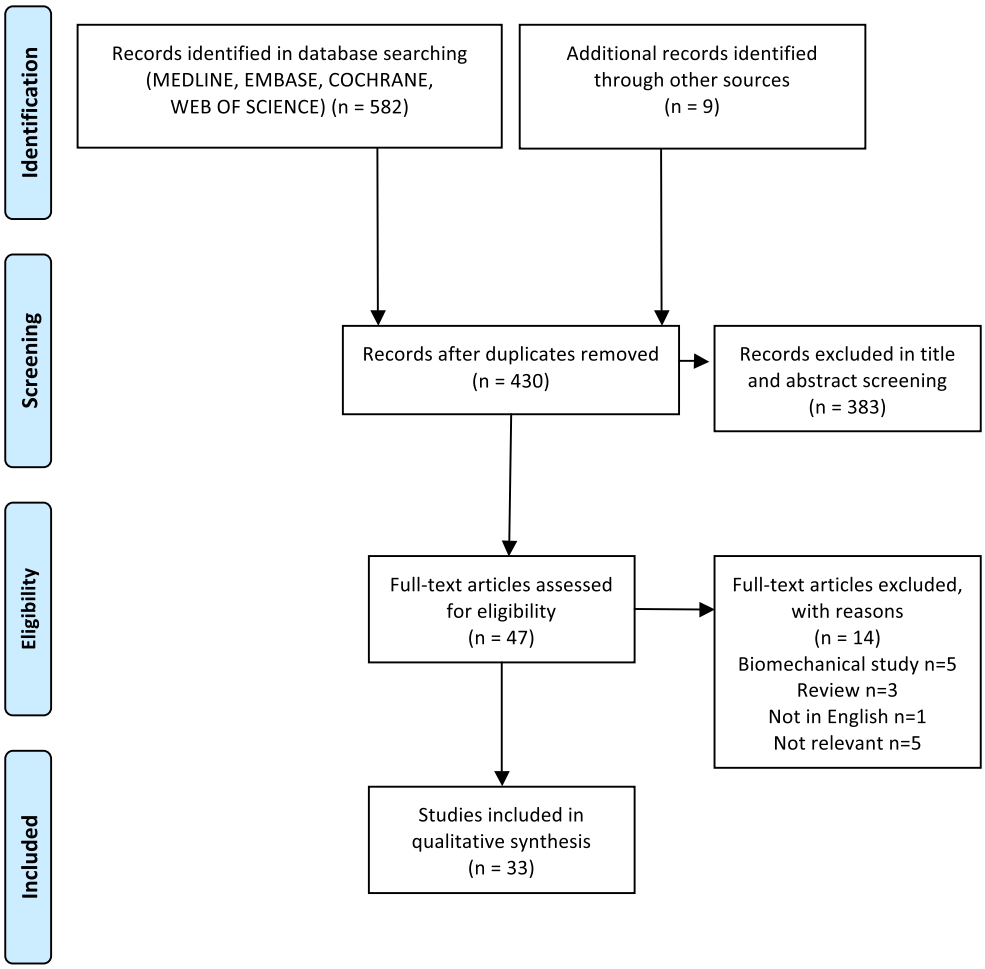

Fig. 1 PRISMA flow diagram [27]. The diagram illustrates the search process for published literature meeting the inclusion criteria for this study

Table 1 Summary of current literatures and for or against for surgical treatment for ankle instability using minimally invasive surgical approach

Surgical technique category	No. of studies	Level I	Level II	Level III	Level IV	Level V	Grade of recommendation	Recommendation
Arthroscopic repair	21	0	0	0	13	8	C	For
Non-arthroscopic* repair	0	0	0	0	0	0	I	NA
Arthroscopic reconstruction	6	0	0	0	1	5	C	For
Non-arthroscopic* reconstruction	6	0	0	2	1	3	C	For

NA not applicable

* Non-arthroscopic minimally invasive

Table 2 Summary of current literature for or against surgical treatment for ankle instability using arthroscopic repair

Surgical technique	No. of studies	Level I	Level II	Level III	Level IV	Level V	Grade of recommendation	Recommendation
Suture anchor	12	0	0	0	7	5	C	For
Thermal shrinkage	7	0	0	0	6	1	C	For
Other	2	0	0	0	0	2	I	For

20, 22, 26, 28, 35, 37] were published after 2009. However, only seven Level IV [1, 5, 6, 20, 22, 28, 37] and five Level V studies [2, 16, 17, 26, 35] were available and variety of surgical technique were reported in this approach.

Suture anchor technique

There were seven Level IV studies about arthroscopic repair using suture anchor [1, 5, 6, 20, 22, 28, 37]. These techniques were thought to produce good clinical and functional results. However, some studies reported concerns over complications and suggested that advanced arthroscopic skills were necessary (Table 2). Five Level V studies [2, 16, 17, 26, 35] described their arthroscopic technique as relatively simple to perform if the surgeon has sufficient ankle arthroscopy experience.

Thermal shrinkage technique

Seven studies [3, 7, 15, 19, 25, 29, 38] included in this review focused on thermal shrinkage of the ATFL or thermal assist capsular shrinkage, with six Level IV [3, 7, 19, 25, 29, 38] and one Level V [15] studies available. These procedures seem to offer many of the same advantages of the Broström procedure and were technically simple with a short convalescence when compared to other techniques designed to stabilize the ankle. Some of these studies suggested further studies would be needed to confirm long-term efficacy of these procedures. Mechanical instability with complete ligament rupture was cited as a relative contraindication to this procedure in many of these studies [3, 7]. Other Level V arthroscopic repair techniques included stapling [14] the use of bone tunnel [24] to avoid the complications of suture anchors.

Grade of recommendation

On the basis of the current literature available, a Grade C recommendation (poor-quality evidence of Level IV and V studies recommending for the use of this intervention) is assigned to arthroscopic repair using suture anchors or thermal shrinkage (in the absence of mechanical disruption of ligaments) approach for the treatment for CAI. The literature available to support the use of staples or bone tunnels during arthroscopic repair deserves Grade I recommendation due to the lack of published evidence on each surgical approach.

Non-arthroscopic minimally invasive repair

We could find no literature mentioning this approach. Therefore, the grade of recommendation regarding the non-arthroscopic minimally invasive repair surgery is Grade I recommendation due to the lack of published evidence on this surgical approach.

Arthroscopic reconstruction

Only one Level IV [32] study and five Level V [11, 12, 23, 33, 34] studies were available regarding arthroscopic reconstruction category of CAI. One level IV [32] study and a Level V [34] study reconstructed only ATFL, and other four Level V [11, 12, 23] studies reconstructed both ATFL and CFL using arthroscopy.

The first report of the arthroscopic reconstruction of the ATFL in our review came from Priano et al. [32] in 1994. In this retrospective case series with 10 patients, they used a pedicle flap of fibular periosteum lowered like a drawbridge from the lateral malleolus to the anterolateral surface of the talus, fixed with anchors set between the remaining ligament fibres, and concluded that this technique was free from risks or substantial drawbacks compared with open surgery. However, it required a long learning curve on the part of the surgeon (Table 3).

The first report on the arthroscopic anatomical reconstruction of both the ATFL and the CFL was by Lui [23]. The calcaneal insertion of the CFL could be identified arthroscopically through the anterolateral portal with the peroneal tendon sheath was stripped through the middle subtalar portal. He created two bone tunnels in fibula to reconstruct ATFL and CFL anatomically. Guillo et al. [11, 12] described a novel arthroscopic ATFL and CFL reconstruction technique in 2014 that utilized peroneal tendoscopy to provide a better view of ATFL and CFL. They describe that endoscopic technique made it possible to carry out anatomical reconstruction with greater accuracy of the tunnel positioning and the view obtained using this technique to be superior to that seen in open surgery [12], but they also mentioned that the procedure especially endoscopic dissection was technically demanding [11]. Prissel et al. [34] reported arthroscopic stabilization reinforced with synthetic ligament for revision or complex primary lateral ankle stabilization, and Piraino et al. [33] also reported their arthroscopic 'recreation' of the ATFL technique with two suture anchors.

Grade of recommendation

On the basis of the previously mentioned literature of this category, arthroscopic reconstruction for CAI would clearly warrant a Grade C recommendation (poor-quality evidence of Level IV and V studies recommending for the use of this intervention). Further, there is no evidence that shows one technique is superior to another for arthroscopic ATFL and CFL reconstruction.

Non-arthroscopic minimally invasive reconstruction

Six studies (two in Level III [43, 44], one in Level IV [39] and three in level V [9, 21, 30]) were found in this review

Table 3 Summary of Level IV evidence supporting arthroscopic repair with anchor suture

Study (year)	Type of study	No of patients	Mean age (range)	Mean follow-up period, month (range)	Outcome			
					Score	Before surgery	Result	Complication rate
Corte-Real et al. (2009) [10]	Level IV (retrospective case series)	28	33.3 (15–54)	27.5 or 24.5 (6–48)	AOFAS	NA	85.3 (65–100)	29 %
					Satisfaction	NA	3.8 (1–5)	
Nery et al. (2011) [28]	Level IV (case series)	38	28.8 (15–53)	9.8 years (5–14)	AOFAS	NA	90 (40–100)	5.30 %
					ADT	NA	Grade 0:25, grade 1:13	
					Talar tilt	NA	2.7 mm (0.4–8)	
Acedevo et al. (2011) [1]	Level IV (case series)	24	39 (15–55)	10.9 (1.5–24)	NA	NA	NA	16.70 %
Kim et al. (2011) [20]	Level IV (retrospective case series)	28	38.6 (22–55)	15.9 (13–25)	AOFAS	60.78 ± 16.38	92.48 ± 6.14	17 %
					ADT difference two ankles	3.59 ± 0.68 mm	0.61 ± 0.75 mm	
Vega et al. (2013) [37]	Level IV (retrospective case series)	16	29.3 (17–46)	29.3 (17–46)	AOFAS	67 (59–77)	67 (59–77)	12.50 %
Cottom et al. (2013) [6]	Level IV (prospective case series)	40	45.6 (15–83)	12.13 (6–21)	AOFAS	41.2 (23–64)	95.4 (84–100)	7.5 %
					VAS	8.2 (4–10)	1.1 (0–5)	
					Karlsson–Peterson score	NA	93.6 (82–100)	
Labib et al. (2015) [22]	Level IV (case series)	14	NA	3 (6w–54w)	AOFAS	NA	92.8 (80–100)	0
					VAS	NA	1.7 (0–4)	

AOFAS American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale score, *ADT* anterior drawer test, *VAS* visual analog scale for pain, *NA* not applicable

for this category: minimally invasive reconstruction without using arthroscopy. All the included studies reconstructed both the ATFL and CFL using autograft or allograft by percutaneous technique with three to six small incisions.

Xu et al. [43] conducted a Level III retrospective comparative case series in 2014 that compared the therapeutic effect between semitendinosus autograft and allograft for ATFL and CFL reconstruction. The study involved 68 patients of which 32 had received the autograft and 36 the allograft, both via a percutaneous technique. They concluded that the clinical outcomes of the two grafts were both excellent, and no significant difference was identified. They also reported a relatively short recovery time for healing with minimal donor site problems in autograft group (Table 3).

Another Level III study by Young et al. [44] reviewed the outcomes of their percutaneous ATFL and CFL reconstruction with a peroneal or hamstring tendon allograft and compared the result between with and without tenodesis screw in fibular bone tunnel. They described their inclusion criteria as a previously failed reconstruction surgery, severe ankle instability (more than 15 degrees of talar tilt, more than 10 mm of anterior drawer), general laxity of ligaments, body mass index (BMI) higher than 25. They concluded that percutaneous reconstruction with allograft was effective as a salvage procedure for the treatment for severe and complicated types of CAI (Table 3).

Wang et al. [39] published a Level IV retrospective case series to evaluate the efficacy of their percutaneous ATFL and CFL reconstruction using a semitendinosus autograft. They concluded that use of this technique in a minimally invasive approach could achieve ankle stability while avoiding extensive exposure and risk of nerve injury (Table 3). Three Level V studies [9, 21, 30] described percutaneous techniques of ATFL and CFL reconstruction.

Grade of recommendation

On the basis of the current literature, non-arthroscopic minimally invasive reconstruction approaches to treat CAI deserves a Grade C recommendation (poor-quality evidence of Level III, IV and V studies recommending for the use of this intervention).

Discussion

The most important finding of the present study was evidence-based support on MIS for the treatment for CAI and that was predominantly Level IV and V evidence. Thirty-three studies [1–3, 5–7, 9, 11, 12, 14–17, 19–26, 29, 30, 32–35, 37–39, 43, 44] have been published on the use of MIS for the treatment for CAI, and 29 studies [1–3, 5–7, 9, 11, 12, 15, 19–26, 29, 30, 33–35, 37–39, 43, 44] were reported after 2000. Most of the studies were Level IV or V evidence. There were two Level III [43] and 15 Level IV [1, 3, 5–7, 20, 22, 28, 29, 32, 37–39, 44] studies in this review, and all supported the use of MIS for the treatment for CAI. Although there has been no consensus on the best score system to use to evaluate clinical efficacy of ankle stabilization surgery [13], most of the studies adopted the American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale (AOFAS) score [5, 6, 20, 22, 28, 37, 39, 43] and followed by stress radiographs [20, 28, 32, 39, 43, 44], patient satisfaction score [5, 32, 39, 44], Karlsson–Peterson score [6, 43] or visual analog scale for pain (VAS) [6, 22]. Only one study [7] adopted patient activity score or general health score (Tables 3, 4). In addition, the complication rate in arthroscopic repair category was reported as high in a past review [40], but the rate in other MIS category was not obvious in this review because of the lack of reporting data (Table 4). Future studies should include their complications to distinguish whether the complication rate of the MIS was higher than that of conventional open technique.

Although the indications for thermal shrinkage were limited to the patient without mechanical instability [3, 7] or mild to moderate ankle instability [25, 29, 38], the indication of each MIS category was not clear in most studies. Most of reconstruction procedure reconstructed both ATFL and the CFL [9, 11, 12, 21, 23, 30, 34, 39, 43, 44]; in contrast, most of the repair procedures identified in this review repaired only ATFL [1–3, 5–7, 14–17, 19, 20, 22, 24–26, 28, 29, 35, 38] with some reinforcing by IER (Gould procedure) [1, 2, 5, 6, 20, 26, 28]. The quality of the existing remnant would be a considerable factor [13]. Reconstruction procedures may be indicated in a patient who requires more robust ankle stabilization such as those patients with high BMI [44], failed repair treatment [21, 44] or coexisting general laxity [44].

In the minimally invasive repair category, all studies [1–3, 5–7, 14–17, 19, 20, 22, 24–26, 28, 29, 35, 37, 38] were categorized into arthroscopic repair category, and there was no study in non-arthroscopic minimally invasive repair category. In the arthroscopic repair category, there was variety of surgical techniques. The most common technique was the repair with suture anchor [1, 2, 5, 6, 16, 17, 20, 22, 26, 28, 35, 37] followed by thermal shrinkage [3, 7, 15, 19, 25, 29, 38]. Even in this small category of arthroscopic repair with suture anchor [1, 2, 5, 6, 16, 17, 20, 22, 26, 28, 35, 37], there were various techniques. The most commonly utilized procedure was one or two anchors introduced from accessory anterolateral portal to the fibula footprint of the ATFL under arthroscopic view, then grasped and sutured the ATFL. The method of grasping and suturing the ATFL with or without the reinforcement with IER accounted for the variation in techniques. Some adopted arthroscopic

Table 4 Summary of Level III and IV evidence supporting arthroscopic or non-arthroscopic minimally invasive reconstruction

Study (year)	Character of surgery	Type of study	No. of patients	Mean age (range)	Mean follow-up period, month (range)	Outcome			
						Score	Before surgery	Result	Complication rate
Xu et al. (2014) [43]	Percutaneous reconstruction with ST autograft or allograft	Level III (retrospective comparative case series)	68						29 %
			Autograft: 32	32.4 ± 2.4	33.5 ± 6.7	AOFAS	62.3 ± 8.2	95.1 ± 7.5	
						Talar tilt	14.0 ± 3.2°	3.8 ± 1.2°	
						Talar shift	12.3 ± 3.2 mm	4.6 ± 1.2 mm	
						Operation time		85.5 ± 11.5 min	
			Allograft: 36	33.2 ± 3.2	28.5 ± 6.7	AOFAS	60.2 ± 8.4	94.8 ± 5.5	
						Talar tilt	13.0 ± 3.5°	3.6 ± 1.4°	
						Talar shift	11.5 ± 2.3 mm	4.3 ± 1.5 mm	
						Operation time	NA	58.1 ± 10.2 min	
Youn et al. (2012) [44]	Percutaneous reconstruction with ST or TP allograft	Level III (comparative case series)	15	29 (21–53)	18.1 (12–40)	VAS	3.7 ± 2.2	1.6 ± 1.3	NA
						Karlsson–Peterson ankle score	54.2 ± 8.8	80.9 ± 7.2	
						Patient's subjective score	NA	'Excellent' or 'good' in 13 cases (86.7 %)	
						ADT	10.1 ± 3.3 mm	7.2 ± 2.7 mm	
						TTA	15.5 ± 4.4°	7.3 ± 3.6°	
Wang et al. (2013) [39]	Percutaneous reconstruction with ST graft	Level IV (retrospective case series)	25	39 (15–55)	32.4 (17–62)	AOFAS	71.1	95.1	NA
						Patient's subjective score	NA	Excellent: 20/ good: 5	
						ADT	12.3 mm	4.6 mm	
						TTA	14.0°	3.8°	
Priano et al. (1994) [32]	Arthroscopic reconstruction with periosteum flap	Level IV (case series)	10	38.6 (22–55)	32 (24–50)	Subjective satisfaction	NA	8 excellent, 2 good	NA
						ADT	6 mm	Less than 4 mm	
						TTA	15°	12–14°	

AOFAS American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale score, *ADT* anterior drawer test, *TTA* talar tilting angle, *VAS* visual analog scale for pain, *NA* not applicable

assist (percutaneous or mini-open) procedure [1, 2, 5, 6, 28], and others adopted purely arthroscopic procedure [26, 35, 37] for this step. Further studies should be conducted to clarify the difference in efficacy and safety between the techniques in this minimally invasive repair category.

In the minimally invasive reconstruction category, non-arthroscopic minimally invasive reconstruction implied percutaneous reconstruction procedure [9, 21, 30, 39, 43, 44]. There were several techniques in this category as well with great variation in construction of the fibular bone tunnels. Most studies did not clarify how anatomically ligaments could be reconstructed. A similar number of studies were included in arthroscopic reconstruction category [11, 12, 23, 32–34]. There was a great deal of variation in the arthroscopic approach for determination of the calcaneal insertion of the CFL that is thought to be an extra-capsular structure and a challenge to identify.

The present study has several strengths. A comprehensive review of the literature was performed identifying all types of MIS techniques used for the treatment for CAI including both repair and reconstruction techniques. Unfortunately, the level of evidence of the available studies was quite low with only two Level III studies [43, 44]. The remaining studies included only one method (Level IV) [1, 3, 5–7, 20, 22, 28, 29, 32, 37–39] or technical note (Level V) [2, 9, 11, 12, 14–17, 21, 23, 24, 26, 30, 33–35]. Furthermore, there was no study available to compare the outcomes of various MIS techniques. Future studies should be done in a prospective manner comparing clinical outcomes and complication rates not only between various MIS techniques but also between MIS and open procedures. This knowledge will assist surgeons in determining the indications for each technique. The clinical relevance of this study was evidence-based recommendation for the use of the MIS in treating CAI. Even the recent advent of the literatures about the MIS for the CAI and all of them concluded that the MIS may be a feasible technique, surgeons should aware that the evidences supporting the use of the MIS were not enough.

Conclusions

A comprehensive review of the literature has provided predominantly Level IV and V evidence on minimally invasive surgery for the treatment for chronic ankle instability. There is limited and poor-quality evidence that supports the use MIS approaches in treating CAI. This may have more to do with lack of evidence than ineffectiveness of these approaches. It is recommended that surgeons currently using MIS techniques for the treatment for CAI should do this in the confines of prospective case series, comparative or randomized controlled trials to provide higher quality of evidence on safety and efficacy.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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