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Review Article

The role of anatomical repair of the anterior inferior tibiofibular ligament in acute ankle fractures with syndesmotic injury: A systematic review

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ABSTRACT

The management of syndesmotic injury in ankle fractures is still controversial. Anterior inferior tibiofibular ligament (AITFL) primary repair is considered essential to reduce the risk of syndesmotic malreduction. This review examined the available literature on primary AITFL repair in ankle fractures. This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. PubMed, Web of Science, Cochrane, and Google Scholar were searched up to July 15, 2021, for articles reporting on the repair of AITFL in acute ankle fractures with syndesmotic injury. The quality of the included studies was assessed using the Newcastle-Ottawa scale. Studies that investigated isolated syndesmotic injury without ankle fracture, reviews, cadaveric studies, case reports, and studies not published in English were excluded from the study. The search yielded 588 articles, of which three studies were included, with a total of 229 AITFL primary repairs. The articles were excluded due to different design, foreign language, irrelevancy, or no syndesmosis injury, including patients with isolated syndesmosis injury or used methods of repair other than anatomical repair. Early functional outcomes were found better after AITFL repair compared to syndesmotic screw fixation alone. Moreover, time to return to play/work was significantly lower in the anatomical repair compared to temporary screw fixation. Anatomical repair of the ankle syndesmosis is an effective and safe method with good functional outcomes and return to activity. However, the future prospective studies are required to assess the efficacy of the anatomical repair of the syndesmosis and its superiority over other treatments.

Keywords: Ankle, Ankle injuries, Fracture, Interosseous membrane, Repair, Syndesmotic injury, Tibiofibular ligament

INTRODUCTION

Historically, syndesmosis injury incidence was reported as low as 1–18% of all ankle sprains. However, with the growing evidence and understanding of the syndesmosis biomechanics, it is reported that such injuries range between 17% and 74% of all ankle sprains.[1] The treatment options for syndesmosis injury are non-operative and operative. The non-operative management of syndesmosis includes immobilization and physiotherapy, whereas the operative management

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includes screw fixation or suture button fixation, especially when the ankle is unstable. The current standard of care for ankle fractures with syndesmotic injury includes reduction and screw fixation without syndesmotic repair. This practice, however, leads to hardware complications requiring screw removal in 10–15% of cases or, in some practices, necessitates obligatory screw removal after healing.[2] Several factors contribute to syndesmotic screw complications, such as heterotopic ossification, malreduction, screw breakage, implant irritation, and limitation of ankle dorsiflexion. These complications are, to some extent, unavoidable with screw fixation. Multiple studies have demonstrated that the rate of syndesmotic malreduction reaches up to 50% regardless of fracture pattern or surgeon experience.[3-6] Moreover, the importance of anatomical syndesmotic repair in rotational ankle fractures is unclear. Still, there is no consensus on the role of the anterior inferior tibiofibular ligament (AITFL) repair in such injuries.[7,8] Therefore, this study aimed to systematically review the available literature on primary AITFL repair in acute ankle fractures with syndesmotic injury.

MATERIALS AND METHODS

Search strategy

PubMed, Web of Science, Cochrane, and Google Scholar were searched up to July 15, 2021, using the following terms and their related MeSH terms; tibiofibular AND Anatom* AND ankle AND fracture.

We included articles that reported acute ankle fracture with injured syndesmosis that underwent open reduction and internal fixation and anatomical repair of the AITFL. In addition, included studies reported post-operative radiological and/or functional outcomes. The exclusion criteria were isolated syndesmotic injury without ankle fracture, reviews, cadaveric studies, case reports, and studies not published in English.

Screening

The search results were uploaded on Rayyan-Intelligent Systematic Reviews software (https://www.rayyan.ai/). In compliance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, the search results were screened and tested against the inclusion criteria by two independent investigators (AT and JS) using the title, abstract, and then full-text method.[9] Any controversy between the two reviewers was solved after a discussion with the senior investigator (MS).

Data collection process and data items

A standardized collection form on Microsoft Office Excel containing the variables of interest was used for data extraction. Two independent investigators performed data extraction and then crosschecked the data. Any discrepancy was solved by a discussion between the two reviewers and the senior author. The following variables were collected; study demographics (author name, publication year, country, and study design), patients' demographics (sample size, type of injury, and type of repair), radiological and functional outcomes, and complications.

Risk of bias in individual studies

Two independent investigators used Newcastle Ottawa Scale (NOS) to assess the included studies' quality. Any discrepancy between the two authors was solved with the guidance of the senior author. The NOS consists of three domains: Comparability, selection, and outcome. The total NOS score ranges between 0 and 9 and the maximum scores that can be achieved for each component are two, four, and three for comparability, selection, and outcome, respectively.[10]

RESULTS

Study selection

The search yielded 588 articles, of which 168 articles were duplicates. The remaining 420 articles were screened using the titles, abstracts, and full text when needed. Four hundred and eleven studies were excluded due to different design, foreign language, irrelevancy, or no syndesmosis injury. The lasting nine articles were reviewed in their full-text form and six of them were excluded for including patients with isolated syndesmosis injury (without ankle fracture) or using different methods of treatment other than anatomical repair. The PRISMA flowchart is displayed in Figure 1.

Study characteristics

All included studies were conducted during the past 5 years (2016–2021). The studies' total number of participants was 229 and all of them had ankle fractures with syndesmotic injury. Fifty patients had OTA-44C, 43 had Weber Type B, and 10 had Weber type C ankle fracture, while the remaining patients were not classified. In the studies that provided data about gender, 61.2% were male. Table 1 summarizes the characteristics of the included studies. Table 2 summarizes the outcome measures used by the included studies.

Quality assessment

The quality assessment results for the included studies are summarized in Table 3. As per NOS, a study with a total of nine stars is considered the study with the highest quality.

Surgical technique

All included articles provided descriptions of the performed surgical intervention. Anatomical AITFL repair with

Table 1: Characteristics of included studies.

Study	Country	Study design	Level of evidence	Treatment technique	Number of participants	Screw fixation	Anatomic repair	Fracture classification
Zuhan *et al.*, 2016	China	Prospective comparative cohort	2	1 – Screw fixation 2 – Anatomical repair	53	26	27	Weber Classification type B and C
Del Balso *et al.*, 2021	Canada	Prospective comparative Cohort	2	1 – Open reduction, screw fixation, and ligament repair 2 – Closed reduction and screw fixation	40	23	17	Weber classification type C
Steinmetz *et al.*, 2016	France	Retrospective cohort	4	Screw fixation and ligament repair	126	0	126	Ankle fracture*

*Did not classify the type of the fracture

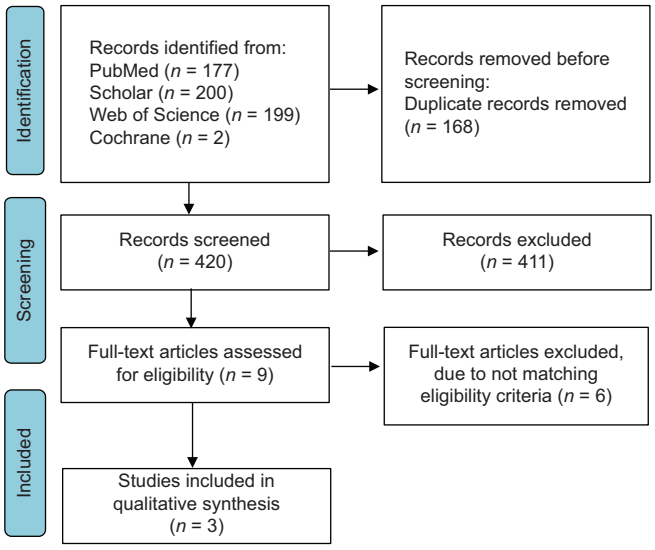

Figure 1: Search strategy flowchart.

temporary screw fixation was used in 143 patients (62.4%), while anatomical AITFL repair without screw fixation was used in 27 patients (11.8%). In addition, reduction with screw fixation was performed in 59 patients (25.7%). The study by Zhan *et al.* included 53 patients, 23 underwent reduction with screw fixation, while 27 underwent reduction with an anatomical repair.[11] Moreover, all the 126 patients in Steinmetz *et al.* study underwent reduction with anatomical repair and temporary screw fixation.[12] In Del Balso *et al.* study, 17 patients underwent reduction with anatomical repair and temporary screw fixation, while 23 patients underwent reduction with screw fixation only.[13]

Functional outcomes

All included studies reported functional outcomes for their patients. The study by Zhan *et al.* showed that the Olerud-Molander ankle score (OMAS), plantar flexion, and dorsiflexion were significantly higher in the open anatomical repair group compared to the screw fixation group at 3–6 months.[11] However, only plantar flexion remained significantly higher in the open anatomical repair group at 12 months of follow-up. Moreover, the study by Steinmetz *et al.* reported that the range of motion among its patients was 95 ± 10% of the contralateral uninjured side and 93 ± 10% of the contralateral uninjured side for plantar flexion and dorsiflexion, respectively.[12] Moreover, at the end of follow-up, the patients' mean of the American Orthopaedic Foot and Ankle Society (AOFAS) score was 93 ± 9, while the mean OMAS score was 93 ± 10. Del Balso *et al.* study showed no significant difference in the total of Maryland foot score at 6 weeks, 3 months, 6 months, and 12 months between the anatomical reduction group and the screw fixation one.[13]

Similarly, there was no significant difference between the groups in all the Maryland foot subscores except for cosmesis and shoe subscores. Accordingly, a significantly higher Maryland foot score (cosmesis) favoring the screw fixation group compared to the anatomical repair group was observed at 6 weeks, while this difference was diminished at 3, 6, and 12 months. In addition, the anatomical repair group had a significantly higher Maryland foot score (shoes) at 12 months compared to the closed reduction group.

Furthermore, there were no differences between anatomical repair and screw fixation at 6 weeks, 3 months, 6 months, and 12 months in the AOFAS hindfoot score. Likewise, apart from the quality-of-life subscore, there were no differences in the Foot and Ankle Orthopedics Score (FAOS) subscores detected between the groups at all follow-up points. The quality-of-life subscore was significantly higher in the anatomical repair group compared to the screw fixation group at 12 months. Zhan *et al.* study reported no difference in the pain measured using the visual analog scale (VAS) score between the two groups at 3, 6, and 12 months.[11]

Table 2: The outcome measures for the included studies.

Study	Zuhan *et al.*, 2016	Del Balso *et al.*, 2021	Steinmetz *et al.*, 2016
Stability	Yes	No	No
Reduction loss	Yes	No	No
Secondary operation	Yes	No	No
Malreduction	Yes	Yes	No
Pain	Yes	No	No
OMAS[1]	Yes	No	Yes
Plantar flexion	Yes	No	No
Dorsiflexion	Yes	No	No
Return to work/play	Yes	No	Yes
Side to side difference	No	Yes	No
Incongruity, mean difference in translation	No	Yes	No
Maryland foot score	No	Yes	No
AOFAS[2]	No	Yes	No
Hindfoot score	No	Yes	No
FAOS[3] score	No	Yes	No
Weather-related pain	No	No	Yes
VAS[4] score	No	No	Yes
Subjective stiffness	No	No	Yes
Objective range of motion	No	No	Yes
Stiff ankle	No	No	Yes
Screw removal	No	No	Yes
Malleolar union	No	No	Yes
Screw height	No	No	Yes
Poor reduction	No	No	Yes
Degeneration	No	No	Yes
Signs of osteoarthritis	No	No	Yes
Osteophyte	No	No	Yes
Secondary diastasis	No	No	Yes

[1]The Olerud-Molander Ankle Score, [2]the American Orthopedic Foot and Ankle Society, [3]Foot and Ankle Outcome Score, [4]the visual analog scale

Table 3: Quality assessment NOS.

Study	Selection	Comparability	Outcome	Total
Zhan *et al.*, 2016	3	2	3	9
Steinmetz *et al.*, 2016	2	0	3	5
Del Balso *et al.*, 2021	3	1	3	7

NOS: Newcastle–Ottawa scale

Steinmetz *et al.*, in which all their patients underwent ATFL repair with temporary screw fixation, reported that the mean VAS was 0.8 ± 1.3.[12]

Return to work/play

Two studies reported the return to work/play in its outcomes. Zhan *et al.* reported that the time to return to work was significantly lower in the anatomical repair group compared to screw fixation only.[11] Furthermore, among the athletes in the study by Steinmetz *et al.*, the mean time away from sports was 10 ± 6.7 weeks.[12] Most of them (82.6%) returned to play similar to their pre-injury level, whereas 16.4% reported a reduction in participation and 1% reported no return to sports. In terms of long-term performance, Steinmetz *et al.* found that 82.6% of athletes return to pre-injury levels. Furthermore, after a 5-year follow-up, there were no signs of degeneration.[12]

Radiological outcomes

Zhan *et al.* study showed that although the stability of the syndesmosis was achieved in all the patients who underwent screw fixation as well as anatomic repair, the syndesmotic screw did not restore AITFL structure integrity and changed the contact between the ruptured ends.[11] Furthermore, the same study reported no significant difference in malreduction between the open repair and screw fixation group. Steinmetz *et al.* reported two cases of poor reduction and after 5 years of follow-up, no signs of degeneration were detected.[12] The study observed eight patients with osteoarthritis, 14 with osteophyte, and seven with secondary diastasis. In comparison, Del Balso *et al.* reported that no cases of malreduction were detected on plain films.[13] In addition, this study reported that a significantly higher translation difference between the injured and non-injured ankle was detected among the screw fixation group that was not detected in the anatomical repair group.

Complications

All the studies reported complications that occurred among their patients. Zhan *et al.* reported that significantly higher overall complications occurred in the screw fixation group compared to the open repair one.[11] However, none of the complications were significantly different between the two groups; reduction loss, wound complications, implant failure, or foreign body reaction. Steinmetz *et al.* study reported that 19 complications occurred postoperatively during the study period.[12] Six of these complications were considered serious and five were infections. In addition, significant ankle stiffness that required arthrolysis occurred twice. Twelve cases of complex regional pain syndrome were reported and all were resolved. Moreover, only one deep vein thrombosis occurred during the study. Furthermore, Del Balso *et al.* reported two cases of screw breakage in the anatomical repair with screw fixation group, while this occurred in seven patients in the screw fixation group.[13] In addition, one case of incomplete ossification of the syndesmosis occurred in the screw fixation group. According to Zhan *et al.,* the difference was not statistically

significant even though screw fixation patients had more malreduction than the AITFL group.[11] In contrast to closed reduction, Del Balso *et al.* demonstrated that AITFL repair before screw helps to avoid rotational and translational malreduction.[13]

DISCUSSION

This systematic review of three studies (229 patients) showed that the anatomical repair of syndesmosis is superior to temporary screw fixation in terms of OMAS, plantar flexion, and dorsiflexion but not total Maryland foot score, AOFAS score, or FAOS score. However, all these superiorities in terms of function were diminished at extended follow-up periods except for plantar flexion. Moreover, time to return to play/work was significantly lower in the anatomical repair compared to temporary screw fixation. Furthermore, this study showed that almost all the patients who underwent anatomical repair returned to play with a level similar to the pre-injury level.

Radiological outcomes were similar between the anatomical repair and screw fixation groups in terms of stability and risk of malreduction. In addition, the anatomical repair was significantly associated with lower complications compared to temporary screw fixation.

Similar to our results, the previous studies showed that using anatomical repair in treating ankle fractures with AITFL injury restored the stability of the ankle mortise, improved bone repair stability, and allowed for early return to activities and exercise.[14] Furthermore, two of the included articles showed that anatomic repair of the syndesmosis had better outcomes regarding functional outcomes and complications. Moreover, the use of open repair could solve the considerable controversy surrounding the idea of whether to keep the screw or not in metallic syndesmotic screw fixation.[15] A study showed that screw removal was associated with a high risk of complications and should be done only in selected cases.[15] However, another study showed that the removal of screws was associated with favored functional outcomes compared to retained screws.[16]

It was estimated that there are about 6445 syndesmotic injuries in the United States annually.[17] Even though this type of injury was not common compared to other injuries, syndesmotic injuries could lead to severe complications, including ankle arthrosis.[18] Malreduction was proven to be the single modifiable factor for the occurrence of ankle arthrosis.[18] Our study showed that trans-syndesmotic fixation and anatomical repair were similar in the risk of malreduction; hence, none of these interventions offers more protection from ankle arthrosis than the other. In contrast, some studies demonstrated that open repair of syndesmosis was associated with a substantial risk of malreduction, but this risk was lower than closed reduction.[19,20]

In addition, the ability to visualize the quality of reduction in the open repair technique was associated with decreased risk of malreduction by 15–50%.[5,20,21] It was illustrated that the quality of reduction considerably impacted the prognosis and functional outcomes. Thus, it is important to detect any case of incorrect reduction.[22] Some studies showed that this could be done using CT scanning techniques. However, the decision of surgical revision could not be made based on imaging due to the significant anatomical variations among individuals.[6] In addition, arthroscopic techniques could help in the syndesmotic reduction and could be integrated with the use of a flexible stabilization construct.[23,24]

Limitations

Although this is the first systematic review of the anatomical repair of syndesmosis injury with an ankle fracture, the study had several limitations that should be acknowledged. The low number of the included studies limits the generalizability of the results of this review. In addition, the high heterogeneity between the included studies limited the ability to conduct a meta-analysis. Another limitation is that not all the included studies were comparative, making it difficult to know which treatment methods were superior to others. Moreover, the included studies use different tools and methods to assess the functional and radiological outcomes. Consequently, more prospective studies with a larger sample size are needed to assess the safety and efficacy of the methods to treat syndesmotic injuries with ankle fractures and compare different treatment methods. In addition, consensus methods to evaluate the functional and radiological outcomes after treating syndesmotic injuries to be used in the future studies are required.

CONCLUSION

This systematic review shows that the anatomical repair of syndesmosis is superior to temporary fixation in terms of return to play/work, early functional outcome, and complication. However, there is no difference between the two methods in terms of late functional and radiological outcomes. The future prospective studies are required to assess the efficacy and safety of this method and its superiority over other treatment methods.

AUTHORS' CONTRIBUTIONS

AH reviewed the literature, designed the study, collected, organized and interpreted data, and wrote the article. AT collected, analyzed data, and participated in writing the manuscript. JS reviewed the literature and collected data. PM edited the manuscript. PH edited the manuscript. MS reviewed the literature, participated in

writing the manuscript, and supervised data collection and interpretation. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

This article does not contain any studies with human participants performed by any of the authors.

DECLARATION OF PATIENT CONSENT

Patient's consent not required as there are no patients in this study.

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CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

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