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Surgical outcome in chronic syndesmotic injury: A systematic literature review☆

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ABSTRACT

Background: Chronic injuries of the distal tibio-fibular syndesmosis often present with non-specific clinical and radiographic findings. If chronic instability to the distal tibio-fibular syndesmosis is verified, various reconstruction options are available. The purpose of this article is to give a systematic review of current surgical treatment options in patients with chronic syndesmotic injury.
Methods: Three major medical databases were searched from inception through December 12, 2017: PubMed, ScienceDirect, and SpringerLink. Studies were included if they were original research studies which assessed the outcome of patients treated surgically for chronic syndesmotic instability. Only studies written in English were considered. The following data were extracted from each study: number of patients and ankles included, average patients' age, gender, study design, preoperative examination, time between the initial injury and the operation, postoperative follow-up time, operative technique, complication rates, and clinical outcome. The modified Coleman Score was used to assess the methodologic quality of the included studies.
Results: Seventeen (17) studies were included. All studies were retrospective or prospective case series. Each study was performed at a single center. In general, good functional outcomes and low complication rates were reported. The American Orthopaedic Foot and Ankle (AOFAS) score was most frequently used outcome tool to measure postoperative outcomes. The quality of the included studies was overall satisfactory.
Conclusions: A few studies have reported on the operative outcomes after treating chronic syndesmotic instability. Several different techniques were used to treat this problem. The quality of current studies is overall satisfactory but could be improved with larger patient numbers and prospective analysis. Recognition of this clinical entity as an identifiable and treatable cause of ankle pain requires vigilant clinical investigation.
Level of evidence: Level IV; Systematic Review of Level IV Studies.

1. Introduction

Chronic injuries of the distal tibio-fibular syndesmosis often present with non-specific clinical and radiographic findings [1–3]. Up to 18% of all ankle sprains and approximately 23% of all ankle fractures show an additional syndesmotic injury [4–6]. Injury to any of the four ligaments that comprise the syndesmosis (anterior inferior tibio-fibular ligament [AITFL]; interosseous membrane [IOM]; posterior inferior tibio-fibular ligament [PITFL]; transverse tibio-fibular ligament [TTFL] are often accompanied with deltoid ligament injuries [5,7,8]. Chronic instability and degenerative changes of the ankle joint and therefore physical impairments and pain may occur if syndesmotic injuries are undiagnosed at the initial visit [2,3,9].

Assessment of the distal tibio-fibular syndesmosis is difficult, especially in case of chronic instability [10,11]. Next to conventional weight-bearing radiographs, magnet resonance imaging (MRI) is widely used to assess chronic injuries [11]. However, MRI findings may not correlate with clinical symptoms, leading to overestimation or underestimation of injury severity and complexity [11]. Therefore, a thorough medical history and clinical examination are important in all patients with chronic posttraumatic ankle pain. In the case of chronic pain but normal radiographic findings, arthroscopy can help to further assess the

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integrity of the distal tibio-fibular syndesmosis [12,13]. If chronic instability to the distal tibio-fibular syndesmosis is verified, various reconstruction options are available. While debridement may be sufficient in some patients, others need a more complex reconstruction like an osteotomy, medialization and proximalization of the tibial insertion of the AITFL and/or a reconstruction of the AITFL with an autograft [12,14]. In long standing disorders, a tibio-fibular fusion may be necessary [15]. However, there is no systematic review available assessing the outcomes, complication rates, and the quality of currently used operative techniques addressing chronic syndesmotic instability.

The objective of this article is to systematically review current surgical options of chronic syndesmotic instability.

2. Materials and methods

2.1. Data source

Three major medical databases were searched from inception through December 12, 2017: PubMed, ScienceDirect, and SpringerLink. The bibliographies of articles of interest were additionally reviewed. There were no limitations on type of journal or publication date of the article. Only articles in English were included. The following keywords were used: syndesmosis/-otic AND instability; syndesmosis/-otic AND injury; syndesmosis/-otic AND augmentation; syndesmosis/-otic AND fixation. The systematic literature search was performed by two reviewers (N.K and M. W.W.).

2.2. Study selection

Outcome studies were included if they were original research studies (excl. cadaver studies) which assessed the outcome of patients treated surgically for chronic syndesmotic instability. Studies were excluded if they used incomplete data (i.e. missing clinical outcome), had an average follow-up of less than 12 months, were published as either case reports or review articles, included less than five patients, and/or were written in another language than English. Furthermore, studies that did not have their full text available on the aforementioned sources were excluded. The study selection process was conducted independently by two reviewers (N.K. and M.W.W.). The decision to include or exclude the study was based on group consensus.

2.3. Data extraction

The following data were extracted from each outcome study: number of patients and ankles included, age, gender, study design (prospective vs. retrospective, single-vs. multicenter, level of evidence), preoperative examination, time between the initial injury and the operation, postoperative follow-up time, operative technique, and clinical outcome (incl. ankle specific outcome scores, complication rate). Data extraction was performed by two reviewers (N.K. and M.W.W.).

2.4. Study quality assessment

The modified Coleman score was used to assess the quality of the included outcome studies [16]. Each study was evaluated for study size, mean follow-up time, number of surgical procedure used, type of study, diagnostic certainty, description of surgical procedure, and description of postoperative rehabilitation. Additionally, each study was evaluated for outcome criteria, procedure for assessing outcome, and description of the selection process.

2.5. Statistical analysis

The quality of the imaging studies included in our analysis was assessed by using the Coleman score [16]. Pooled means were calculated for patients' age, postoperative follow-up time, and time between injury and surgery.

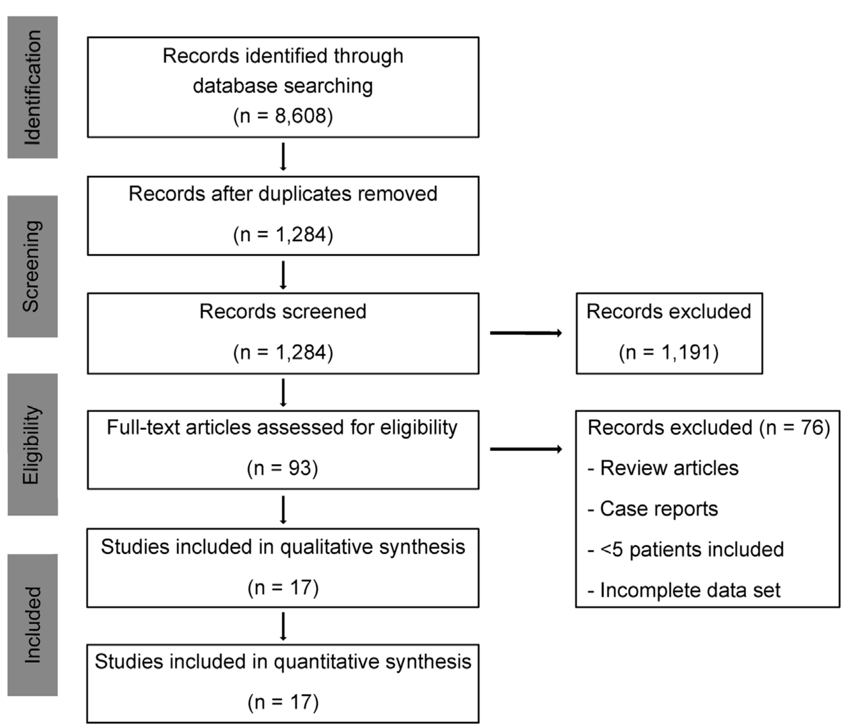

Fig. 1. Flow chart depicting the strategy used to select relevant studies. The literature search was done according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).

3. Results

3.1. Included studies

The initial screening showed 8608 studies which potentially could be included (Fig. 1). After removing all duplicates and reviewing the title and abstract of each study, 93 outcome studies were available for further more detailed assessment. After exclusion of review articles, case reports, articles including <5 patients, articles with incomplete data set or not available as a full-text article, 17 outcome studies were ultimately included in the final analysis. Data screening was done according to the guidelines of “Preferred Reporting Items for Systematic Review and Meta-Analyses” (PRISMA).

3.2. Study characteristics

In total, 196 patients (196 ankles) were evaluated (Table 1). While one study was a prospective case series (level of evidence IV), all remaining studies were retrospective case series (level of evidence IV) [17]. Each study was performed as a single center study. With the exception of two studies, included articles reported the average patients’ age [18,19]. One of the studies which did not report the patients’ age included a larger cohort of patients with different pathologies and reported the average patient age of the whole group [18].

3.3. Surgical treatment

The pooled mean time between injury and surgical treatment was 18.2 (range 1.5–252 months) and was reported in all but two studies [18,19]. A pronation external rotation injury was the most frequently reported initial trauma. Indication for operative treatment was most frequently based on the clinical examination (e.g. pain over the distal tibio-fibular syndesmosis, positive external rotation test) combined with conventional radiographs of the ankle joint (Fig. 2). The tibio-fibular clear space (TFCS) and tibio-fibular overlap (TFO) were frequently assessed using a

Table 1
Demographics and characteristics of clinical studies highlighting surgical treatment of chronic syndesmosis instability.

Author	Cohort		Pro vs. retro	Single vs. multi	LoE	Coleman score (total)	Duration of symptoms	Surgery description
	Patients	Ankles						
Katznelson et al. [32]	5	5	Retro	Single	IV	45	9.5 months (2–24)	Tibio-fibular fusion
Ogilvie-Harris and Reed [12]	17	17	Retro	Single	IV	58	24 months (9–64)	Arthroscopy and debridement
Ogilvie-Harris et al. [18]	9	9	Retro	Single	IV	55	nr	Arthroscopy and debridement
Beumer et al. [14]	9	9	Retro	Single	IV	69	27 months (4–102)	Two stages: (1) arthroscopy and debridement; (2) osteotomy of a bone block at the tibial insertion of the AITFL, one positioning screw
Harper [30]	6	6	Retro	Single	IV	59	15 months (3–26)	Tibio-fibular debridement in 4 cases, medial joint space debridement in 2 cases; one or two tri- or quadri-cortical positioning screws (4.5, 6.5 or 7.3 mm)
Grass [20]	16	16	Retro	Single	IV	58	14 months (two patients 19 and 21 years post injury)	Split peroneus longus ligamentoplasty, one positioning screw
Beumer et al. [21]	5	5	Retro	Single	IV	59	17 months (10–33)	Two stages: (1) arthroscopy and debridement; (2) osteotomy of a bone block at the tibial insertion of the AITFL, one positioning screw
Han et al. [17]	10	10	Pro	Single	IV	68	22 months (±15)	Arthroscopy, debridement, one positioning screw
	10	10						Arthroscopy and debridement
Schuberth et al. [31]	6	6	Retro	Single	IV	61	14.3 months (3–58)	Arthroscopy, debridement, two to three positioning screws (4.5 mm)
Morris et al. [22]	8	8	Retro	Single	IV	64	13 months (3–28)	Two stages: (1) arthroscopy and debridement; (2) reconstruction with a free hamstring allograft, one positioning screw (4.5 mm)
Zamzami and Zamzam [23]	11	11	Retro	Single	IV	54	56.4 months (24–120)	Arthroscopy, debridement, open reconstruction with a free semitendinosus autograft, one positioning screw (4.5 mm)
Olson et al. [15]	10	10	Retro	Single	IV	54	9 months (2–21)	Tibio-fibular fusion (two 3.5 mm screws lagged thorough a plate)
Wagener et al. [28]	12	12	Retro	Single	IV	64	24 months (6–84)	Two stages: (1) arthroscopy and debridement; (2) osteotomy of a bone block at the tibial insertion of the AITFL, one positioning screw
Yasui et al. [24]	6	6	Retro	Single	IV	64	16 months (10–27)	Arthroscopy, debridement, open reconstruction with a free gracillis autograft, one 3.4 mm positioning screw (3 patients had fibular osteotomy and plating)
Jain and Kearns [25]	5	5	Retro	Single	IV	59	10 months (7–16)	Ligamentous advancement technique (arthroscopy, debridement, open reduction, AITFL reconstruction, two hole plate screws)
Colcuc et al. [26]	10	10	Retro	Single	IV	55	11 months (7–15)	Arthroscopy, suture of AITFL, one positioning screw (3.5 mm), one suture-button
	12	12						Arthroscopy, periosteal flap, one positioning screw (3.5 mm), one suture-button
	10	10						Arthroscopy, plantaris tendon (autograft), one positioning screw (3.5 mm), one suture-button
Ryan and Rodriguez [19]	19	19	Retro	Single	IV	64	At least 12 months	Arthroscopy, debridement, two to three suture-buttons

Values are given as mean and standard deviation or range.
nr, not reported; pro, prospective; retro, retrospective; LoE, level of evidence; AITFL, anterior inferior tibio-fibular ligament.

Fig. 2. 36-years old male patient who sustained a complex ankle sprain. (2-A) Non weight-bearing antero-posterior (AP) radiograph shows a distinct incongruence within the ankle joint. (2-B) Computed tomography (CT) scan (coronal plane) shows a suspicious widening of the distal tibio-fibular syndesmosis. (2-C) Normal position of fibula in the sagittal plane, evidence of a bony avulsion of the posterior syndesmosis.

weight-bearing AP or mortise view of the ankle joint. Additional computed tomography (CT) scans were performed in four studies, while magnet resonance imaging (MRI) was done in five studies [15,17,20–26]. Operative treatment included arthroscopy in 13 articles (Fig. 3). Out of them, a two-stage procedure (arthroscopy followed by a reconstruction of the syndesmosis in a later session) was performed in four studies (Table 1) [14,21,22,28]. Using arthroscopy, a tibio-fibular distance of 2 mm or more was defined as tibio-fibular instability in several studies [29]. The most frequently performed operative technique included ankle arthroscopy, debridement of the tibio-fibular joint with syndesmosis stabilization using a positioning screw (3 studies), or suture button (1 study, Fig. 4) [17,19,30,31]. Three studies performed debridement of the tibio-fibular joint without insertion of a positioning screw [12,17,18]. AITFL reconstruction with a tendon transfer was performed in five studies, but each study used a different technique that incorporates a different tendon autograft: the semitendinosus tendon, the gracillis tendon, the plantaris tendon, and the split peroneus longus tendon [20,23,24,26]. One study used an unspecified tendon from the hamstring [22]. In each of those studies, a positioning screw was used for temporary protection of the ligamentous reconstruction. Direct repair of the AITFL (one study used an additional periostal flap) or a tibio-fibular fusion was done in two studies each [15,25,26,32]. Overall, the pooled mean age of patients treated for chronic syndesmotic instability was 37.9 (range 17.0–71.0) years. The pooled mean follow-up time was 29.0 (range 6.0–120.0) months (12 studies).

3.4. Outcome and complications

The American Orthopaedic Foot and Ankle (AOFAS) score was most frequently used to measure outcomes (10 studies), followed by the Karlsson Ankle Functional Score (KAFS), used in three studies. Ten studies reported pre- and postoperative outcome scores. The postoperative outcome score increased in each of them. All studies provided information regarding postoperative complications (Table 2). In general, a low rate of complications was reported. Each study which used a positioning screw for temporary protection of the reconstruction performed a hardware removal around 6–8 weeks postoperative. Only one study reported a grading system for degenerative changes of the tibio-fibular joint over time, while another study which performed tibio-fibular arthrodesis reported tibio-talar arthritis over time [14,15]. The first study did only report postoperative degenerative changes at the latest follow- up, while in the second study, no progression of ankle joint osteoarthritis was evident.

3.5. Quality assessment

The quality of the included studies was overall satisfactory. Retrospective single center studies were performed most frequently, possibly limiting the generalizability of the findings. The small sample size of the studies was another limitation of quality, with most studies including less than 20 patients. In addition, outcome scores with unknown reliability and sensitivity (e.g. AOFAS hindfoot score) were used in the most studies.

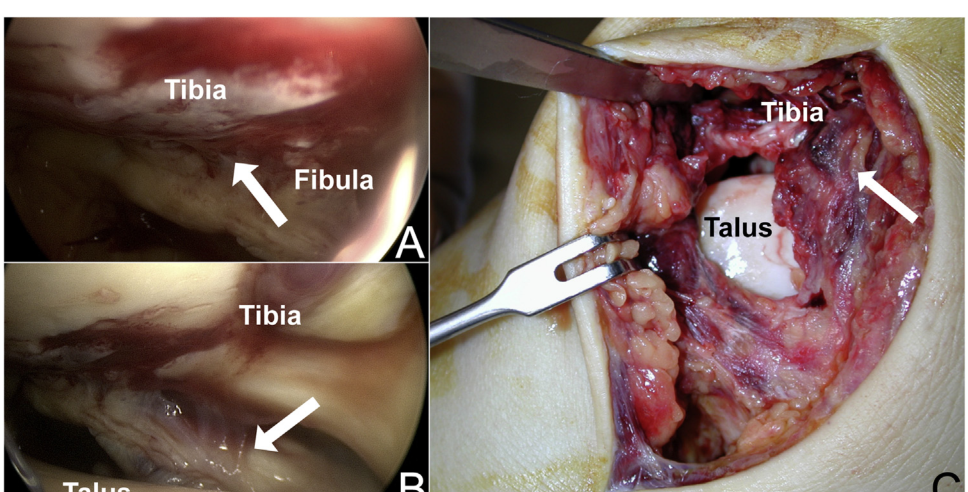

Fig. 3. Surgical evaluation of the ankle joint. (3-A) Arthroscopy shows hematoma and rupture (arrow) of the anterior inferior tibio-fibular ligament (AITFL). (3-B) Non-displaced bony avulsion (arrow) of the posterior inferior tibio-fibular ligament (PITFL). (3-C) Open exploration confirms rupture of the AITFL (arrow).

Fig. 4. Intraoperative radiographic evaluation. (4-A) Positive hook-test. (4-B) Congruent ankle joint after tibio-fibular fixation using a tight-rope. (4-C) Tibio-fibular stability is confirmed by the hook test.

Table 2
Complications in clinical studies highlighting surgical treatment of chronic syndesmosis instability.

Author	Dissatisfied		Recurrence		Re-operation			Nerve injury		Infection		CRPS	
	Number	%	Number	%	Number	%	Reason	Number	%	Number	%	Number	%
Katznelson et al. [32]	nr	nr	0	0.0	5	100	Hardware removal (5)	0	0.0	0	0.0	1	20.0
Ogilvie-Harris et al. [29]	1	5.9	1	5.9	nr	nr	nr	1	5.9	nr	nr	nr	nr
Ogilvie-Harris et al. [18]	0	0	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr
Beumer et al. [14]	nr	nr	0	0.0	9	100	Hardware removal (9)	1	11.1	nr	nr	2	22.2
Harper [30]	1	16.7	1	16.7	6	100	Hardware removal (6) Tibio-fibular arthrodesis (1)	nr	nr	nr	nr	nr	nr
Grass et al. [20]	nr	nr	0	0.0	16	100	Hardware removal (16)	0	0.0	0	0.0	nr	nr
Beumer et al. [21]	0	0.0	0	0.0	5	100	Hardware removal (5)	nr	nr	nr	nr	nr	nr
Han et al. [17]	nr	nr	nr	nr	nr	nr	nr	0	0.0	0	0.0	nr	nr
Schuberth et al. [31]	0	0.0	0	0.0	6	100	Hardware removal (6)	0	0.0	0	0.0	0	0.0
Morris et al.[22]	1	16.7	1	16.7	8	100	Hardware removal (8)	nr	nr	nr	nr	nr	nr
Zamzami and Zamzam [23]	1	9.1	0	0.0	11	100	Hardware removal (11)	nr	nr	nr	nr	nr	nr
Olson et al. [15]	0	0.0	0	0.0	3	30.0	Hardware removal (2) Arthroscopy (1)	nr	nr	0	0.0	nr	nr
Wagener et al. [28]	0	0.0	0	0.0	12	100	Hardware removal (12)	0	0.0	1	8.3	0	0.0
Yasui et al. [24]	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr
Jain and Kearns [25]	nr	nr	nr	nr	5	100	Hardware removal (5)	1	20.0	nr	nr	nr	nr
Colcuc et al. [26]	nr	nr	nr	nr	32	100	Hardware removal (32) Infection (1) Suture granuloma (2)	nr	nr	1	3.1	nr	nr
Ryan and Rodriguez [19]	nr	nr	0	0.0	4	21	Hardware removal (2) Neurogenic pain (1) Suture granuloma (1)	2	11.0	0	0.0	nr	nr

nr, not reported.

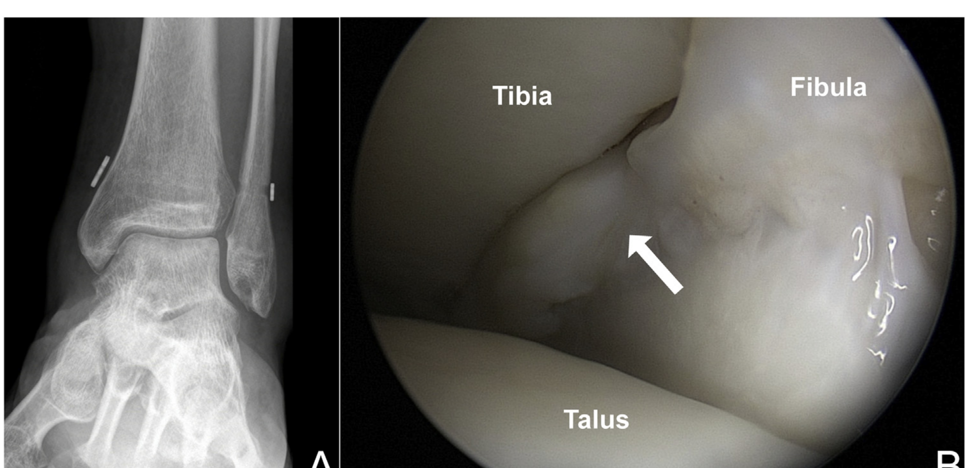

Fig. 5. Persistent pain and evidence of tibio-fibular instability nine months after surgery. (5-A) Antero-posterior (AP) radiograph shows tibio-fibular widening. (5-B) Arthroscopy reveals a scarred and insufficient (arrow) anterior inferior tibio-fibular ligament (AITFL).

4. Discussion

A systematic review of the surgical outcomes for treatment of chronic syndesmotic injuries was performed. Seventeen (17) studies were included and assessed regarding quality, outcome and complications. The four most relevant findings were: (1) only few articles exist assessing the surgical outcome of chronic syndesmotic injuries; (2) retrospective case series are the most frequently used study design; (3) many different operative techniques are used to address chronic syndesmotic injuries; (4) no standardized algorithm for preoperative assessment is available; (5) patients demonstrate improvement in patient outcome scores (AOFAS and KAFS) following surgical intervention.

Chronic syndesmotic instability is defined as posttraumatic injuries to the syndesmotic ligaments combined with clinical impairments (e.g. pain over the syndesmotic area, feeling of instability) lasting longer than six months (Fig. 5) [3]. Operative treatment for this rare condition varies significantly between the authors. While a tibio-fibular fusion was performed for each patient in the first report in 1983, arthroscopic debridement (IOM and posterolateral cartilage of the tibial plafond) alone was proposed in later studies [12,18,32]. Good clinical results with minor complications were reported for both operative techniques. The authors of the debridement only studies argued that scar tissue between the fibula and tibia is the main cause of pain and that tibio-fibular instability only has a minor influence on patient satisfaction [12]. The same treatment option was re-investigated later in a prospective randomized study (debridement vs. debridement and insertion of a positioning screw) [17]. The clinical outcome for the debridement only group was slightly lower compared to the patients treated with an additional positioning screw. However, the difference was insignificant, wherefore the authors concluded that arthroscopic debridement may be sufficient if no additional instability of the deltoid ligament is present.

Using arthroscopy, a tibio-fibular distance of 2 mm or more was used in several studies as cut-off value to distinguish between a stable and instable syndesmosis [29]. Of note, Colcuc et al. established a more detailed grading system for decision making [26]. Three techniques were retrospectively analyzed in this study. Instability was graded by a tibio-fibular distance of less than 1.5 mm, 1.5–2.5 mm and >2.5 mm. Suturing of the AITFL, reconstruction with a periosteal flap, and reconstruction using a gracillis tendon graft were compared. The third group showed slightly worse clinical results, but patients were overall satisfied in each group. However, it is questionable if this grading system has any advantages to the previous established grading system.

In five studies, open or arthroscopic debridement was performed, followed by a reconstruction of the AITFL with a tendon transfer and temporary insertion of a positioning screw [20,22–24,26]. Because different tendons were used for reconstruction in each study, it is unclear which technique results in the best clinical outcome in terms of tibio-fibular stability and donor site complications (Fig. 6). Other authors performed a two-stage treatment with arthroscopic debridement and instability assessment [14,21,22,28]. If instability was confirmed, the syndesmosis was reconstructed a few weeks later. However, two-stage procedure may be disadvantageous in terms of costs and patients' safety. Tibio-fibular fusion was performed in two studies, and also showed good functional results with minor complications [15,32]. This procedure should be reserved as a salvage procedure for patients with degenerative changes of the tibio-fibular joint. Of note, corrective osteotomies of the distal fibula may be necessary if posttraumatic malunion of the distal fibula is evident [3,15].

Assessment of chronic syndesmotic instability is controversial. Clinical history (posttraumatic chronic pain over the syndesmotic area during daily activities) and clinical examination (pain to palpation over the AITFL, swelling, and positive external rotation test) were used in almost every included study. In addition, conventional radiographs were generally used for assessment of the syndesmotic area. However, there are no cut-off values available for the most commonly used measurement techniques (TFCS, TFO) in chronic syndesmotic lesions. In addition, it is well known that conventional radiographs do not reliably predict syndesmotic injuries [10]. CT scans, which were used in four studies, allow for a more detailed assessment of the syndesmotic area and better visibility of bony avulsions and posttraumatic deformities [27]. MRI was also frequently used and has a high diagnostic accuracy [33]. However, correlating MRIs with patients' complaints might be difficult in chronic injuries. Overall, currently available radiographic methods cannot predict chronic syndesmotic instability reliably.

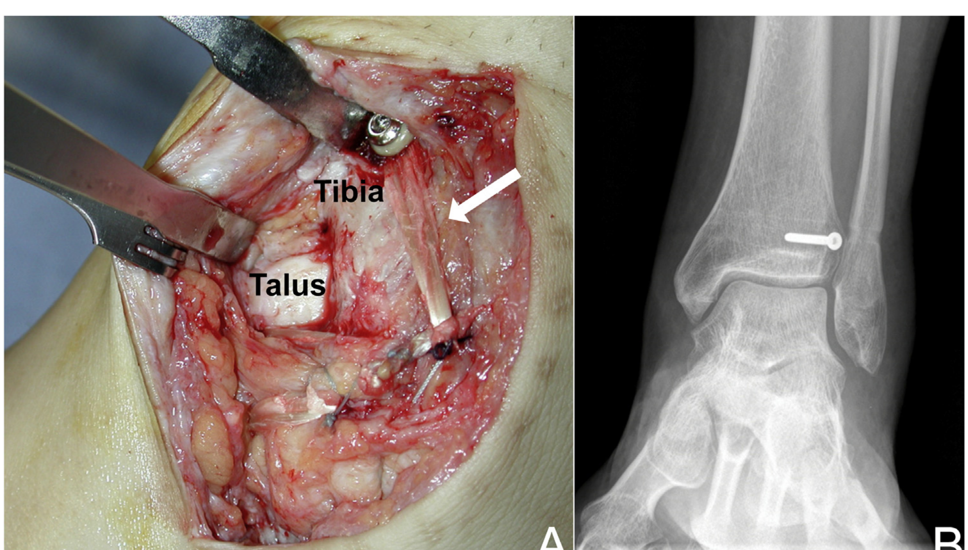

Fig. 6. Revision surgery nine months after the initial operative treatment. (6-A) Intraoperative situs after reconstruction of anterior inferior tibio-fibular ligament with a free plantaris tendon graft. (6-B) Radiographic assessment six months after revision surgery shows a congruent joint. The patient is pain-free and has regained former sports level.

Only a few review articles are available assessing outcome studies of surgically treated chronic syndesmotic injuries [2,3,34–36]. Most of them are narrative reviews and did not systematically review the available literature. Nevertheless, most articles reported an increase of postoperative outcome scores for patients treated surgically for chronic syndesmotic injuries.

This systematic review has several limitations. First, some studies may be missing in this report, especially if they were written in languages other than English. Second, some of the articles included patients with subacute syndesmotic injuries (time between injury and operative treatment <6 months). Third, the heterogenic treatment options of the included studies may reduce the validity of this review. One should be aware that systematic review articles have no influence on quality issues of the included studies. Review articles are limited on their validity if the quality of the included studies is insufficient. Therefore, a strength of our analysis is the use of a well-established quality assessment score [16]. Such a system allows the reader to easily identify a study as either low or high quality.

To conclude, few studies have reported on the operative outcomes after treating chronic syndesmotic instability. Several different techniques were used to treat this problem. The quality of current studies is overall satisfactory but could be improved with larger patient numbers and prospective analysis. Recognition of this clinical entity as an identifiable and treatable cause of ankle pain requires vigilant clinical investigation.

Conflict of interest

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