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Treatment of a Scientifically Neglected Ankle Injury: The Isolated Medial Malleolar Fracture. A Systematic Review

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ABSTRACT

Isolated medial malleolar fractures are frequently encountered injuries. Literature regarding their treatment, though, is scarce and contradicting. The aim of this systematic review is to compare surgical and conservative treatment of isolated medial malleolar fractures considering complication rates and functional outcomes. PubMed, Embase, Cochrane, and CINAHL were searched for this review. Articles from 1980 or later, written in English, French, German, or Dutch, reporting any outcome of 10 or more isolated medial malleolar fractures in skeletally mature patients were included. Study quality was assessed using the Methodological Index for Non Randomized Studies (MINORS) instrument. Eighteen studies were included involving 2566 isolated medial malleolar fractures, which showed a mean (± SD) MINORS score of 8 ± 2. Mean nonunion rate was 1.7% after surgical treatment and 3.5% after conservative treatment. Overall, comparable functional outcomes were found after both treatment methods. Only 2 of the included studies reported the exact amount of fracture displacement. One study—comparing surgical and conservative treatment—showed similar functional outcomes for 1- and 2-mm displaced isolated medial malleolar fractures, and the other, a nonunion rate of 3.5% and a good mean functional outcome in 57 conservatively treated isolated medial malleolar fractures with a mean displacement of 3.8 mm. The available evidence is scarce and of low quality but suggests that conservative treatment of isolated medial malleolar fractures displaced ≤2 mm is safe. No study exists that compares surgical and conservative treatment in isolated medial malleolar fractures displaced >2 mm. Therefore, further research is needed. Until then, the eventual choice of treatment for isolated medial malleolar fractures displaced >2 mm, might be mainly dependent on the patients' characteristics and demands.

Ankle fractures, representing 9% of all fractures, are among the most common types of fractures worldwide (1). Since the 1950s, a rise in the incidence of ankle fractures was observed in several countries (2–4). Medial malleolar fractures most often occur concomitant with associated ankle injury (5,6). Approximately 1 of 5 ankle fractures is an isolated medial malleolar fracture (IMMF) (6,7), increasing to 19% in patients treated at major trauma hospitals (5). Before an ankle fracture can be classified and treated as an IMMF, associated ankle injuries should be ruled out. Fractures of the proximal fibula are especially notorious for being overlooked in the presence of a medial malleolar fracture (8). Furthermore, in the case of a supination-adduction type 2 (SA-2) injury, according to Lauge-Hansen and Ankelbrud (9), involvement of the tibial pilon is eminent and instability of the ankle joint frequent. Therefore, these fractures are not considered IMMFs.

In general, surgical treatment of ankle fractures is performed to prevent long-term post-traumatic arthritis and allows for functional recovery as early as possible. Historically, IMMFs were treated surgically, as these fractures were notorious for painful nonunions (10). More recently, however, it was concluded that all IMMFs should be treated conservatively (11). Others advise to only treat all nondisplaced or minimally (≤2 mm) displaced IMMFs conservatively (12,13). Taken together, the indication for surgery or conservative treatment of IMMFs remains unclear (8). The aim of this systematic review is to compare the number of complications and the functional outcome of surgically and conservatively treated IMMFs in skeletally mature patients.

Materials and Methods

A published review protocol does not exist. No ethical committee approval was necessary for this literature review.

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Table 1
MINORS assessment criteria

Methodological items	2	1	0
Aim	Aim or hypothesis including clear outcomes has been reported	Aim or hypothesis has been reported without a clear outcome	Not reported
Inclusion of patients	Explicit inclusion and exclusion criteria have been reported	Unclear or poor description of inclusion and exclusion criteria has been reported	Not reported
Data collection	Prospective	Retrospective	Not reported
Endpoints	Outcomes are appropriate to the aim of the study	Outcomes are not appropriate to the aim of the study	Not reported
Assessment of endpoints	Blind evaluation of objective outcomes and double-blind evaluation of subjective outcomes	Blinding of one or more outcomes has been reported	Blinding not performed or not reported
Follow-up period	≥1 year	<1 year	Not reported
Loss to follow-up	≤5%	>5% and ≤20%	Not reported or >20%
Study size	Power analysis has been performed	Explanation of study size has been reported	Power analysis and explanation of study size not reported

Search Strategy and Selection Criteria

A systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (14). Two reviewers (R.L. and D.S.) created a search syntax using the following keywords: "ankle fracture" or "medial malleolus" and "surgical" or "conservative." The extensive search syntax for each database was constructed using synonyms and MeSH Terms for the keywords (Appendix 1). On May 1, 2018, 1 reviewer (R.L.) searched Medline, Embase, The Cochrane Library, and CINAHL.

Published RCTs and observational studies discussing outcomes of surgically or conservatively treated IMMFs published after January 1, 1980, and written in English, Dutch, German, or French were included. Studies considering any outcome of ≥10 IMMFs in skeletally mature patients were included. In addition, studies describing both outcomes for ≥10 skeletally mature patients with IMMFs and outcomes for patients with other (ankle) fractures, were included. Considering these studies, only the data of IMMFs were extracted. Studies not discussing malleolar fractures or studies discussing exclusively lateral or posterior malleolar fractures were excluded. Grey literature (e.g., conference abstracts, editorials, and dissertations), letters, surgical technique studies, biomechanical studies, and reviews were excluded. No other exclusion criteria were applied. After removing duplicate articles, titles and abstracts were screened, whereupon the remaining articles were read in full text. No filters were applied. Two reviewers (R.L. and D.S.) assessed the eligibility for inclusion. In case of discussion, a third independent reviewer (R.H.) was consulted to reach consensus. Citation tracking and reference screening of the selected studies were performed.

Quality Assessment

Two reviewers (R.L. and D.S.) applied the Methodological Index for Non Randomized Studies (MINORS) to evaluate the quality of the included studies. MINORS is a validated tool to evaluate the methodological quality of observational studies (15). Further details on the quality assessment are shown in Table 1. In the case of a discussion in the quality assessment process, a third independent reviewer (R.H.) was consulted to reach consensus.

Data Extraction

One reviewer (R.L.) extracted the following data: first author, year of publication, study design, mean follow-up time, fracture type, treatment groups, used surgical treatment including fixation material and postoperative protocol, used conservative treatment, number, age and sex of patients with an IMMF, and the amount of displacement of the IMMF. The following outcomes were extracted: number of nonunion, functional outcome (using, e.g., the American Orthopedic Foot and Ankle Society [AOFAS] score or the Olerud-Molander Ankle Score [OMAS]), and number of other complications (e.g., malunion, revision surgery, or infection) (16,17).

Outcome Measures

The primary outcome was fracture nonunion. To evaluate the effectiveness and safety of surgical and conservative treatment, the following secondary outcome measures were used: functional scores (AOFAS score, OMAS, and other reported functional scores), malunion, revision surgery, implant removal, infection rate (superficial and deep), irritation of osteosynthesis material, and complication not further specified. Revision surgery was defined as a re-intervention requiring anesthesia, except for implant removal due to irritation of osteosynthesis material. Deep infection was defined as an infection that needed surgical debridement. Any reported wound infection that did not need surgical debridement was defined as a superficial infection. Only outcomes concerning IMMFs were extracted from the included articles. When this was not possible, articles were excluded.

Statistical Analysis

Nominal and ordinal variables were described using frequencies with percentages. For continuous variables, means with SDs were used. In the event data were not reported apart for IMMFs, the demanded data were, if possible, calculated from the original articles by 1 of the reviewers (R.L.). If SDs were not reported, these were estimated by dividing available ranges by 4 (18). Outcomes were considered statistically significant if a p value of <.05 was reported.

Results

Search

The electronic search is summarized in Fig. 1. Ultimately, a total of 18 studies met the inclusion criteria (11,12,19–34). Citation checking and reference checking of these articles did not result in any relevant additional articles.

Quality Assessment

The MINORS score was used to assess the quality of the included studies (Table 1). The MINORS score was applied on all 18 studies, which gave a mean (± SD) MINORS score of 8 ± 2. The prospective study and the RCT also scored low, but above average (21,28). In Table 2, the scores are shown for the individual studies.

Baseline Characteristics

Three studies (17%) compared surgical and conservative treatment (12,27,34), 14 (78%) studied surgical treatment (19–26,28–33), and 1 (6%) conservative treatment (Table 3) (11). In total, 2566 patients with IMMFs were included. The number of included patients in the studies ranged between 10 and 1676. Of all the patients, 2517 were treated surgically and 153 conservatively. Five studies included exclusively patients with IMMFs (11,12,22,32,33). In the other studies, the included patients were part of a larger study group. Therefore, baseline characteristics were available for 268 of the included patients. This group consisted of 177 men and 91 women, with a mean age of 38 years (Table 3).

Treatment Methods

In the included studies that used surgical treatment, different fixation methods and postoperative protocols were used (Table 4). Conservative treatment differed considerably between the conservatively treated patients (Table 4).

Outcomes

Complication rates and functional outcomes were not reported in all studies (Table 5). Outcomes for the 3 studies comparing surgical and conservative treatments are shown separately (Table 6) (12,27,34).

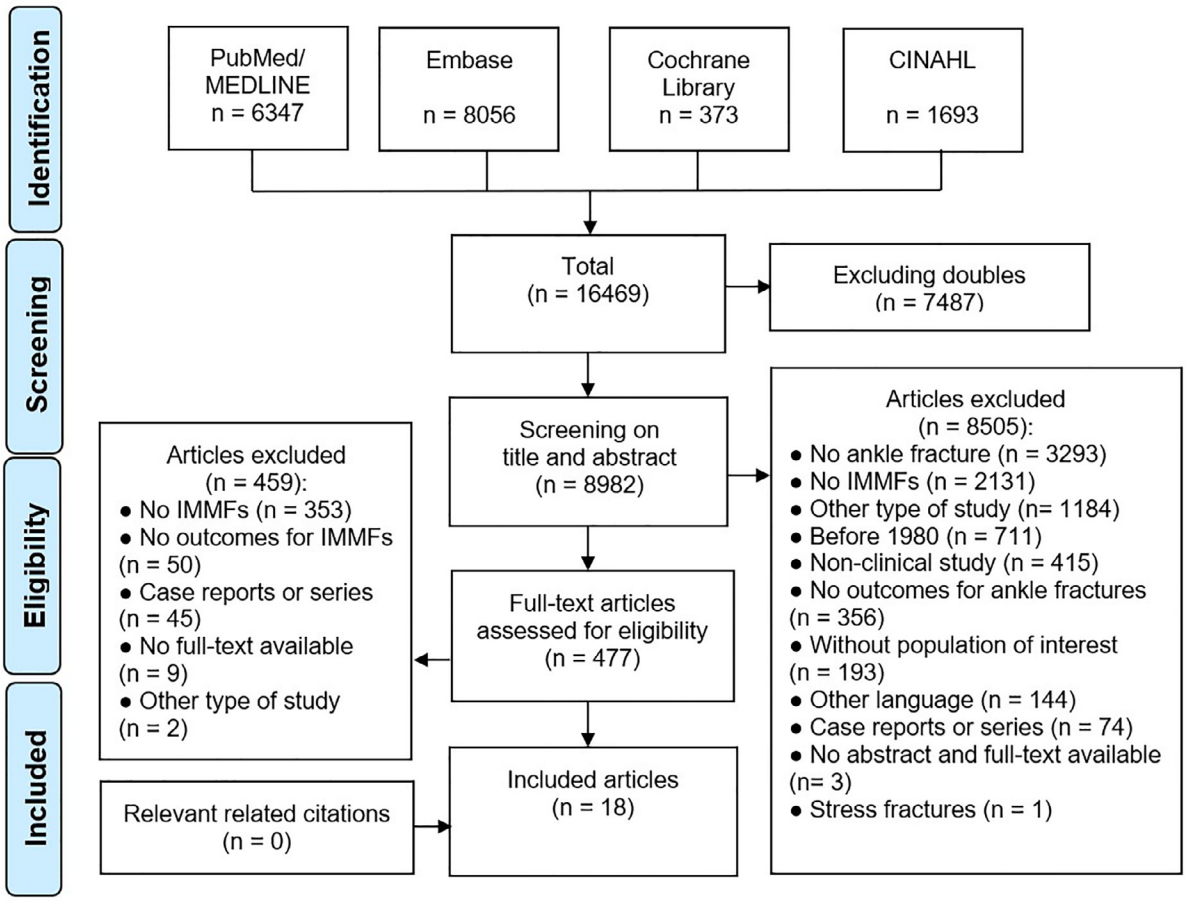

Figure 1. Flowchart search. Other type of study: grey literature (e.g., conference abstracts, editorials, and dissertations), (systematic) reviews, or letters. Non-clinical study: biomechanical or animal studies. Without population of interest: articles concerning skeletally immature patients. Other language: articles not written in English, Dutch, German, or French. Case reports or series: articles concerning <10 patients. Abbreviation: IMMFs, isolated medial malleolar fractures.

Nonunion

Nonunion was reported in 30 (1.7%) of the 1803 surgically treated patients and in 2 (3.5%) of the 57 conservatively treated patients. The nonunion rate differed considerably among the surgical studies. One study—reporting complications using complication registration codes—reported a nonunion rate of 1.8% in 1676 IMMFs (24), and 5 smaller studies described no nonunions in the 95 IMMFs they comprised (22,25,26,32,33).

Malunion, Deep Infection, and Revision Surgery

Malunion was described in none of the 80 surgically treated patients in which malunion was reported. Malunion was not described for conservatively treated patients. A deep infection was described in 53 (2.9%) of the 1840 patients. Deep infection rates differed from 0% in 5 studies with less than 20 patients (19,26–28,32) to 6.4% in a study comparing open reduction with arthroscopy-assisted surgical treatment in 47 patients (33). In the study using registration codes, a deep infection rate of 2.9% was reported in 1676 patients (24). Revision surgery was needed in 13 (0.7%) of the 1818 surgically treated patients and in 2 (1.8%) of the 110 conservatively treated patients. Within studies describing surgical treatment, revision surgery rates differed from 0% in the 3 smaller studies (22,26,32) to 6.4% in the same study that reported a high deep infection rate (33). The study using registration codes reported revision surgery in 0.5% of the 1676 patients (24). Within studies describing conservative treatment, 1 study described revision surgery in 3.5% of the 57 patients (11) and another study in 0% of the 53 patients (12).

Implant Removal and Irritation of Osteosynthesis Material

Implant removal was described in 15 (8.9%) of the 168 patients in which implant removal was reported. Implant removal rates ranged from 3.3% to 19%. Irritation of osteosynthesis material was reported in 9 (0.5%) of the 1796 patients and within the different studies this rate differed from 0% to 10.5%. The study using registration codes reported irritation of osteosynthesis material in 0.2% of the 1676 patients (24).

Functional Outcome

Overall, surgically treated patients performed well according to the different functional scoring systems used. The study using OMAS presented a mean score of 89.0 in 47 patients (33). Another study using the American Academy of Orthopaedic Surgeons foot and ankle survey showed correspondingly good outcomes with an average score of 91.8 ± 1.9 in 19 patients (32,35). Another study—comparing 3 different surgical treatment methods—showed a mean AOFAS score of 94.6 ± 5.6 in 32 patients (22). Of the 4 surgical studies using descriptive outcome scores (19,20,25,26), 2 articles exclusively reported excellent and good outcomes (19,25). Only 1 of these

Table 2
Quality assessment using the MINORS score (N = 18 prior publications)

Criteria	Beris et al (19)	Broos et al (20)	Bucholz et al (21)	Bulut et al (22)	Gris et al (23)	Hanhisuanto et al (12)	Herscovici et al (11)	Hunter et al (24)	Kanakis et al (25)	Koslowsky et al (26)	Kulloli et al (27)	Lindsjö (28)	Maniar et al (29)	McDonald et al (30)	Olsen et al (31)	Rutter et al (32)	Turhan et al (33)	Vécsei et al (34)
Aim	1	2	2	2	0	2	1	2	0	0	1	2	1	2	2	1	1	1
Inclusion of patients	2	1	2	2	0	2	2	2	0	1	2	1	2	2	2	2	2	1
Data collection	0	0	2	1	1	1	1	0	0	0	0	2	1	1	1	1	1	0
Endpoints	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2
Assessment of endpoints	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Follow-up period	2	2	2	2	2	2	2	0	2	0	1	2	1	1	0	2	2	2
Loss to follow-up	0	2	1	0	0	1	2	0	1	1	1	2	0	0	0	1	0	0
Study size	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	7	9	11	9	4	11	10	6	5	4	7	11	6	8	7	9	8	6

studies reported bad outcomes (20). The 57 conservatively treated patients showed good outcomes for IMMFs, with a mean AOFAS score of 89.8 ± 7.8 (11).

Within the studies comparing surgically and conservatively treated IMMFs, 1 study showed comparable functional outcome for both groups (27). In another study, both groups showed comparable results, as the surgical treatment group showed 1 patient (16.7%) with poor results and the conservative treatment group showed 5 patients (13.5%) with poor results (34). The study of Hanhisuanto et al. (12) compared outcomes of 60 surgically with 53 conservatively treated IMMFs. The functional outcome scores did not differ significantly between the surgical (OMAS of 84.9 ± 20.7) and conservative (OMAS of 86.9 ± 17.0) groups.

Amount of Displacement

Only 2 studies reported the exact amount of displacement (11,12). In both studies, the conservative treatment consisted of short-leg casts which were used for 6 weeks. Except for 3 patients, the surgical treatment consisted of open reduction and screw fixation. In the study of Hanhisuanto et al. (12), the surgically treated patients showed a mean displacement of 2.20 mm and the conservatively treated of 1.13 mm, indicating a possible selection bias. Among the conservatively treated group, patients with a fracture displacement of 0 or 1 mm showed a better mean OMAS than patients with a fracture displacement of 2 mm, respectively 92.9 ± 9.9, 90.0 ± 17.8, and 79.4 ± 18.2. Among the surgically treated group, patients with a fracture displacement of 1 or 2 mm showed significantly better average OMAS than patients with >2 mm fracture displacement, respectively 86.6 ± 21.0, 92.1 ± 10.2, and 69.3 ± 27.0. In this study, the mean OMAS for 1- and 2-mm displaced IMMFs was comparable for the surgically and conservatively treated patients. In the study of Herscovici et al. (11), 57 patients were treated conservatively with a mean displacement of 3.8 mm. Despite this large amount of displacement, patients showed a mean AOFAS score of 89.8 and 2 nonunions. The 2 patients with a nonunion had IMMFs with an initial displacement of 3 and 4 mm, respectively. These patients were treated by open reduction and bone grafting. After 4 months, union was achieved in both cases.

Discussion

This study shows that IMMFs with a displacement of ≤2 mm are not prone to cause nonunions after either surgical or conservative treatment. Therefore, previously mentioned concerns are groundless and belong to the past (10). In addition to a relatively low nonunion rate, the included studies show comparable good functional outcomes for both surgically and conservatively treated IMMFs. However, the extracted available evidence considering the treatment of IMMFs is small and the quality of this evidence is low. This suggests that the IMMF is scientifically a neglected type of ankle fracture, which is particularly strange as IMMFs are frequently encountered injuries (5-7), and some even conclude that IMMFs might have a worse prognosis compared to isolated lateral malleolar fractures (20).

It appears that in IMMFs, the amount of fracture displacement determines the functional outcome, regardless of the treatment strategy (12). Unfortunately, only 2 of the included studies reported the exact amount of fracture displacement (11,12). These 2 large studies—both of relatively good quality—show that no nonunions were found in IMMFs with ≤2 mm fracture displacement when treated conservatively and that surgical treatment does not significantly increase functional outcome (11,12). Therefore, conservative treatment for IMMFs displaced ≤2 mm appears to be safe, with good functional outcome reported.

Table 3
Baseline characteristics of the included studies (N = 18 prior publications)

Study	Year	Study Design	Follow-Up Time (months)	Groups	Number of Patients/Feet	Displacement in mm	Age (years)	Male/Female
Beris et al (19)	1997	RC	103* (range 24* to 144*)	Surgical	11/11	NR	NR	NR
Broos et al (20)	1991	RC	12*	Surgical	NR/63	NR	NR	NR
Bucholz et al (21)	1994	RCT	37 (range 21 to 59)	Surgical	30/30	≥2	NR	NR
Bulut et al (22)	2018	RC	24.2 (±10.0, range 12 to 55)	Surgical	32/32	NR	34.9 (±13.5, range 21 to 71)	24/8
Gris et al (23)	2005	RC	36 (±5.6, range 2 to 131)	Surgical	27/27	NR	NR	NR
Hanhisuanto et al (12)	2016	RC	9.9 (±2.6)	Surgical	60/60	2*	38 (±17, range 16 to 75)	45/15
			9.0 (±3.0)	Conservative	53/53	1*	37 (±18, range 16 to 75)	38/15
Herscovici et al (11)	2007	RC	36* (range 25 to 86)	Conservative	57/57	3.8*	39.7 (range 17 to 69)	33/24
Hunter et al (24)	2017	RC	NR	Surgical	NR/1676	NR	NR	NR
Kanakis et al (25)	1990	RC	42* (range 18* to 72*)	Surgical	13/13	NR	NR	NR
Koslowsky et al (26)	2007	RC	NR (max 34)	Surgical	16/16	>0	NR	NR
Kulloli et al (27)	2014	RC	11 (range 9 to 15)	Surgical	6/6	NR	NR	NR
				Conservative	6/6	NR	NR	NR
Lindsjö (28)	1985	PC	range 24* to 72*	Surgical	10/10	NR	NR	NR
Maniar et al (29)	2014	RC	11*	Surgical	14/14	NR	NR	NR
McDonald et al (30)	2014	RC	range 0.2* to 4	Surgical	322/322	NR	NR	NR
Olsen et al (31)	2017	RC	NR	Surgical	61/61	NR	NR	NR
Rutter et al (32)	2015	RC	48 (±3, range 20 to 71)	Surgical	19/19	NR	43 (±4, range 20 to 80)	9/10
Turhan et al (33)	2012	RC	33* (range 18 to 58)	Surgical	47/47	NR	38* (range 22 to 58)	28/19
Vécsei et al (34)	1982	RC	NR	Surgical	6/6	NR	NR	NR
				Conservative	37/37	NR	NR	NR

Abbreviations: NR, not reported; PC, prospective cohort study; RC, retrospective cohort study; RCT, randomized controlled trial.
Data are mean ± SD unless noted otherwise.
* Calculated using data from original article.

Table 4
Used treatment methods in the included studies (N = 18 prior publications)

Study	Year	Groups	Fracture Type–Herscovici Classification	Number of Patients	Treatment Method (Number of Patients)	Postoperative Protocol	Displacement in mm
Beris et al (19)	1997	Surgical	NR	11	Internal fixation NFS	1. 6 weeks immobilization and short leg cast 2. 6 weeks partial WB 3. Full WB	NR
Broos et al (20)	1991	Surgical	NR	63	All fractures were treated following the A0 principles NFS	NR	NR
Bucholz et al (21)	1994	Surgical	NR	18	Bioabsorbable screws	1. Several days cast or brace 2. 6 weeks toe-touch WB 3. Progressive WB	≥2
				12	Stainless steel screws		
Bulut et al (22)	2018	Surgical	Type B	7	Headless, cannulated, fully threaded compression screws (2), cancellous lag screws (2), tension band wiring (3)	1. 1 to 2 weeks immobilization and short-leg brace 2. Start of active and passive range of motion exercises, WB started after evidence of radiographical healing combined with clinical examination	NR
			Type C	11	Headless, cannulated, fully threaded compression screws (4), cancellous lag screws (4), tension band wiring (3)		
			Type D	14	Headless, cannulated, fully threaded compression screws (5), cancellous lag screws (4), tension band wiring (5)		
Gris et al (23)	2005	Surgical	NR	27	Pneumatic staples	1. 5 weeks non-WB cast 2. 4 weeks walking cast	NR
Hanhisuanto et al (12)	2016	Surgical	Type A	5	Screw fixation (57), K-wire and screw fixation (1), K-wire fixation (1), tension band-fixation (1)	1. 5-6 weeks short leg cast, WB differed (non-, partial or full WB) 2. Physiotherapy	2*
			Type B	21			
			Type C	16			
			Type D	18			
		Conservative	Type A	16	1. 5-6 weeks short leg cast, WB differed (non-, partial or full WB) during cast 2. Physiotherapy		1*
			Type B	18			
			Type C	7			
			Type D	12			
Herscovici et al (11)	2007	Conservative	Type A	11	1. 6 weeks short-leg non-WB cast, with the foot in slight inversion 2. Walking boots and physiotherapy		2.8 (range 1-7)
			Type B	6			3.9 (range 1-6)
			Type C	29			4.7 (range 1-11)

(*continued*)

Table 4. (*Continued*)

Study	Year	Groups	Fracture Type—Herscovici Classification	Number of Patients	Treatment Method (Number of Patients)	Postoperative Protocol	Displacement in mm
			Type D	11			2.2 (range 1-5)
Hunter et al (24)	2017	Surgical	NR	1676	Open treatment NFS	NR	NR
Kanakis et al (25)	1990	Surgical	NR	13	Figure-eight tension band wire combined with K-wires	1. 5 days plaster splint 2. Start active movement 3. At day 20 WB of 20 kg was encouraged	NR
Koslowsky et al (26)	2007	Surgical	NR	16	Fine-threaded K-wires	1. 6 days cast 2. Start physiotherapy without WB 3. After 2 weeks start full WB	Yes
Kulloli et al (27)	2014	Surgical	NR	6	NR (used fixation methods for medial malleolar fractures: single malleolar screw, cancellous screw, K-wire or tension band wiring [with 2 screws or K-wire])	1. Below knee plaster, non-WB crutch walking 2. At 6 weeks start partial WB 3. When fracture united start full WB	NR
		Conservative	NR	6	NR (used conservative treatments: short-leg cast and protected WB or long-leg cast for 6 weeks followed by a fracture brace)		NR
Lindsjö (28)	1985	Surgical	NR	10	NR (used fixation methods for malleolar fractures: screws, Zuggurtung, plates and screws, or cerclage)	1. Few days of joint exercises 2. 6 weeks below-knee walking plaster, full WB	NR
Maniar et al (29)	2014	Surgical	NR	10	Conventional screws	1. 2 weeks non-WB or toe touch WB in splint 2. 4 weeks CAM boot with early range of motion exercises and toe touch WB 3. Full WB	NR
				4	Newly designed sled	1. 2 weeks non-WB or toe touch WB in splint 2. 2 weeks early partial WB 3. Extend to full WB	
McDonald et al (30)	2014	Surgical	NR	322	NR (Typical used management consisted of immediate or delayed surgery based on soft tissue swelling and joint congruity, followed by postoperative splinting)	1. 6 weeks cast or protective boot, non-WB for 6–8 weeks	NR
Olsen et al (31)	2017	Surgical	NR	61	NR (The standard surgical procedure involved ORIF with screws and plates. Occasionally, wires or staples were used)	1. 3 weeks plaster or walking cast, non-WB 2. 3 weeks plaster or walking cast, partial WB	NR
Rutter et al (32)	2015	Surgical	Type C Type D	18 1	Wire-form fixation device Wire-form fixation device	1. 2 weeks splint, non-WB 2. 4 weeks short-leg cast or a CAM walker boot, non-WB 3. 2 weeks CAM walker boot, progressive WB 4. Tennis shoe	NR
Turhan et al (33)	2012	Surgical	Type B Type C Type D Type B Type C Type D	6 13 2 6 16 4	Arthroscopy assisted reduction - 2 cannulated screws (7) - 1 cannulated screw and a K-wire (14) Conventional ORIF - 2 cannulated screws (14) - 1 cannulated screw and a K-wire (12)	1. 6 weeks toe-touch WB, active range of motion exercises 2. After 2 weeks start of passive range of motion exercises 3. After 6 weeks full WB was permitted	NR
Vécsei et al (34)	1982	Surgical	Type B/C Type D	4 2	Screws (3), Zuggurtung (1) Cerclage (2)	NR	NR
		Conservative	Type A Type B/C Type D	8 17 12	Cast (6.1 weeks average) Cast (7.6 weeks average) Cast (9.4 weeks average)		NR

Abbreviations: CAM, controlled ankle movement; NFS, not further specified; NR, not reported; ORIF, open reduction and internal fixation; WB, weightbearing.

Table 5
Outcomes of the included studies (N = 18 prior publications)

	Nonunion		Malunion		Revision Surgery		Wound Infections	Functional Scores		Implant Removal	Irritation of OSM	Complication NFS
Study	Surgical	Conservative	Surgical	Conservative	Surgical	Conservative	Surgical	Surgical	Conservative	Surgical	Surgical	Surgical
Beris et al (19)	NR		NR		NR		Sup: NR Deep: 0/11	Baird and Jackson SS: 11 good or exc, 0 fair, 0 poor		NR	NR	NR
Broos et al (20)	NR		NR		NR		NR	AFSS: 24 exc, 25 good, 5 fair, 9 bad		NR	NR	NR
Bucholz et al (21)	NR		NR		NR		NR	NR		1/30 (3.3%)	NR	NR
Bulut et al (22)	0/32		0/32		0/32		NR	AOFASS 94.6 (±5.6, range 83 to 100)		5/32 (15.6%)	NR	NR
Gris et al (23)	NR		NR		NR		NR	NR		5/27 (18.5%)	2/27 (7.4%)	NR
Hanhisuanto et al (12)	NR	NR	NR	NR	1/60 (1.7%)	0/53	Sup: NR Deep: 1/60 (1.7%)	OMAS: 84.9 (±20.7) FAOS (s): 79.4 (±17.6) RAND36 (pf): −11.2 (±28.7) VAS (p): 12.4 (±21.1)	OMAS: 86.9 (±17.0) FAOS (s): 83.1 (±18.2) RAND36 (pf): −1.2 (±21.7) VAS (p): 13.1 (±19.0)	3/60 (5.0%)	2/60 (3.3%)	NR
Herscovici et al (11)		2/57 (3.5%)		NR		2/57 (3.5%)			AOFASS: 89.8 (±7.8*, range 69 to 100) SF-36: 48.1 (±10.5*, range 28 to 60)			NR
Hunter et al (24)	30/1676 (1.8%)		NR		9/1676 (0.5%)		49/1676 (2.9%)	NR		NR	3/1676 (0.2%)	NR
Kanakis et al (25)	0/13		0/13		NR		NR	AFSS: 12 exc, 1 good, 0 fair, 0 poor		NR	NR	NR
Koslowsky et al (26)	0/16		0/16		0/16		Sup: 0/16 Deep: 0/16	AFSS: 11 exc, 4 good, 1 fair, 0 poor		NR	NR	NR
Kulloli et al (27)	NR	NR	NR	NR	NR	NR	Sup: NR Deep: 0/6	UFSS: 3 exc, 2 good, 1 fair, 0 poor	UFSS: 2 exc, 3 good, 1 fair, 0 poor	NR	NR	NR
Lindsjö (28)	NR		NR		NR		Sup: NR Deep: 0/10	NR		NR	NR	NR
Maniar et al (29)	NR		NR		NR		NR	NR		NR	0/14	NR
McDonald et al (30)	NR		NR		NR		NR	NR		NR	NR	16/322 (5.0%)
Olsen et al (31)	NR		NR		NR		Sup: 2/61 (3.3%) Deep: 1/61 (1.6%)	NR		NR	NR	NR
Rutter et al (32)	0/19		0/19		0/19		Sup: 1/19 (5.3%) Deep: 0/19	AAOSS: 91.8 (±1.9) SMFA (f): 67.5		1/19 (5.3%)	2/19 (10.5%)	NR
Turhan et al (33)	0/47		NR		3/47 (6.4%)		Sup: NR Deep: 3/47 (6.4%)	OMAS: 89.0* (±7.5*, range 70 to 100)		NR	NR	NR
Vécsei et al (34)	NR	NR	NR	NR	NR	NR	NR	UFSS: 2 exc, 3 good, 1 poor	UFSS: 14 exc, 18 good, 5 poor	NR	NR	NR

Abbreviations: AAOSS, American Academy of Orthopaedic Surgeons Foot and Ankle Survey score; AFSS, a functional scoring system; AOFASS, American Orthopaedic Foot and Ankle Society score; exc, excellent; FAOS (s), Foot and Ankle Outcome Score, subscore symptoms; NFS, not further specified; NR, not reported; OMAS, Olerud-Molander Ankle Score; OSM, osteosynthesis material; RAND36 (pf), RAND36 health-related quality-of-life questionnaire, subscore physical functioning; SF-36, Short-Form-36 general health scale; SMFA (f), Short Musculoskeletal Form Assessment, function index; SS, scoring system; Sup, superficial; UFSS, unknown functional scoring system; VAS (p), Visual Analogue Scale, performance 1 to 100 (mm).
Data are mean ± SD unless noted otherwise.
* Calculated using data from original article.

Table 6
Outcomes of studies comparing surgical and conservative treatment of IMMFs (N = 3 prior publications)

Study	Groups	Number of Patients	Displacement in mm	Treatment Method (Number of Patients)	Functional Scores	Nonunion	Malunion	Revision Surgery	Wound Infections	Implant Removal	Irritation of OSM
Hanhisuanto et al (12)	Surgical	60	2*	Screw fixation (57) K-wire and screw fixation (1) K-wire fixation (1) Tension band-fixation (1)	OMAS: 84.9 (±20.7) FAOS (s): 79.4 (±17.6) RAND36 (pf): -11.2 (±28.7)	NR	NR	1/60 (1.7%)	1/60 (1.7%)	3/60 (5.0%)	2/60 (3.3%)
	Conservative	53	1*	Short leg cast (53)	OMAS: 86.9 (±17.0) FAOS (s): 83.1 (±18.2) RAND36 (pf): -1.2 (±21.7)	NR	NR	0/53			
Kulloli et al (27)	Surgical	6	NR	NR	UFSS: 3 exc, 2 good, 1 fair, 0 poor	NR	NR	NR	Sup: NR Deep: 0/6	NR	NR
	Conservative	6	NR	NR	UFSS: 2 exc, 3 good, 1 fair, 0 poor	NR	NR	NR			
Vécsei et al (34)	Surgical	6	NR	Screw fixation (3) Zuggertung (1) Cerclage (2)	UFSS: 2 exc, 3 good, 1 poor	NR	NR	NR	NR	NR	NR
	Conservative	37	NR	Cast (37)	UFSS: 14 exc, 18 good, 5 poor	NR	NR	NR			

Abbreviations: exc, excellent; FAOS (s), Foot and Ankle Outcome Score, subscore symptoms; NR, not reported; OMAS, Olerud-Molander Ankle Score; OSM, osteosynthesis material; RAND36 (pf), RAND36 health-related quality-of-life questionnaire, subscore physical functioning; Sup, superficial; UFSS, unknown functional scoring system.
Data are mean ± SD unless noted otherwise.
* Calculated using data from original article.

Additionally, patients with IMMFs displaced >2 mm show low complication rates and a fair mean functional outcome after surgical treatment (12). In the other study, 57 patients were treated conservatively with a mean displacement of 3.8 mm, resulting in a 4% nonunion rate and good functional outcome (11). Considering these outcomes and risk of operative complications, conservative treatment for IMMFs displaced >2 mm seems to be an option that can be considered. Nevertheless, none of the included studies directly compared surgical and conservative treatment of IMMFs with >2 mm fracture displacement. Additionally, these studies did not analyse the stability of the ankle. A type-D IMMF (Herscovici classification), for example, should not be mistaken for a supination-adduction stage 2 injury (9,11), as these fractures have concomitant ligamentous injury on the lateral side of the ankle and therefore are considered unstable. Furthermore, these fractures frequently involve the tibial pilon and therefore need surgical treatment (36).

An advantage of surgical treatment, for example, is a decrease of the non-weightbearing period. What is more, a recent meta-analysis shows that patients with ankle fractures benefit from active mobilization and protected early weightbearing (37). Non-weightbearing regimens result in less mobile patients, which can keep patients from work and result in costs for alternative transportation methods. In the included studies, a non-weightbearing regimen of 6 weeks was most often used in conservatively treated patients (11,12,27,34). However, up to 9 weeks of cast immobilization was reported (34). Additionally, every patient has different needs and demands. Polytrauma patients or elite athletes, for example, could start to rehabilitate earlier as a result of surgical treatment of an IMMF. Furthermore, in current practise, therapeutic decisions are made by shared decision-making. One of the benefits of shared decision-making is that it can lead to less anxiety over the care process, increased patient satisfaction, and improved health outcomes (38,39). Taking the previously mentioned considerations into account, the choice of treatment for IMMFs with >2 mm displacement might be mainly dependent on the patients' characteristics and demands. A suggested flowchart for the treatment of IMMFs is shown in Fig. 2.

This study has several limitations. First, our search—identifying 16,469 articles—seems to be too broad. However, to gather all available evidence on IMMFs, both type of articles were included: articles exclusively concerning IMMFs and articles concerning different types of ankle fractures and reporting any outcome of IMMFs. Therefore, several patients were included for whom the follow-up, age, sex, fracture type, and displacement were not reported. Another limitation of this study is that the reported mean complication rates were highly dependent on 1 study. Retrospectively, the study of Hunter et al. (24) reported complication rates of 1676 IMMFs based only on registered complication codes. Additionally, we were not able to perform a meta-analysis due to the small amount of studies comparing surgical and conservative treatments. The limitations enumerated above are partially the result of the scarce available evidence on this subject. Therefore, all different types of patients and IMMFs are lumped together. Even so, recommendations can be made only on the available evidence. Evidently, further research is needed, especially a study comparing surgical and conservative treatment for IMMFs displaced >2 mm. These future studies should account for type of (surgical) intervention and postoperative regimen, the existence of lateral ligamentous ankle injury, amount of fracture displacement, and patient characteristics.

In conclusion, there is little evidence for the type of treatment of IMMFs, and the quality of available evidence is low. However, when other injuries are ruled out, IMMFs show a relatively low complication rate and good functional outcome. Conservative treatment for IMMFs with ≤2 mm fracture displacement seems to be safe, as no nonunions were found when treated conservatively, and surgical treatment did not increase functional outcome. For IMMFs displaced >2 mm, no evidence exists directly comparing surgical and conservative treatment. The available evidence suggests for IMMFs displaced >2 mm that there

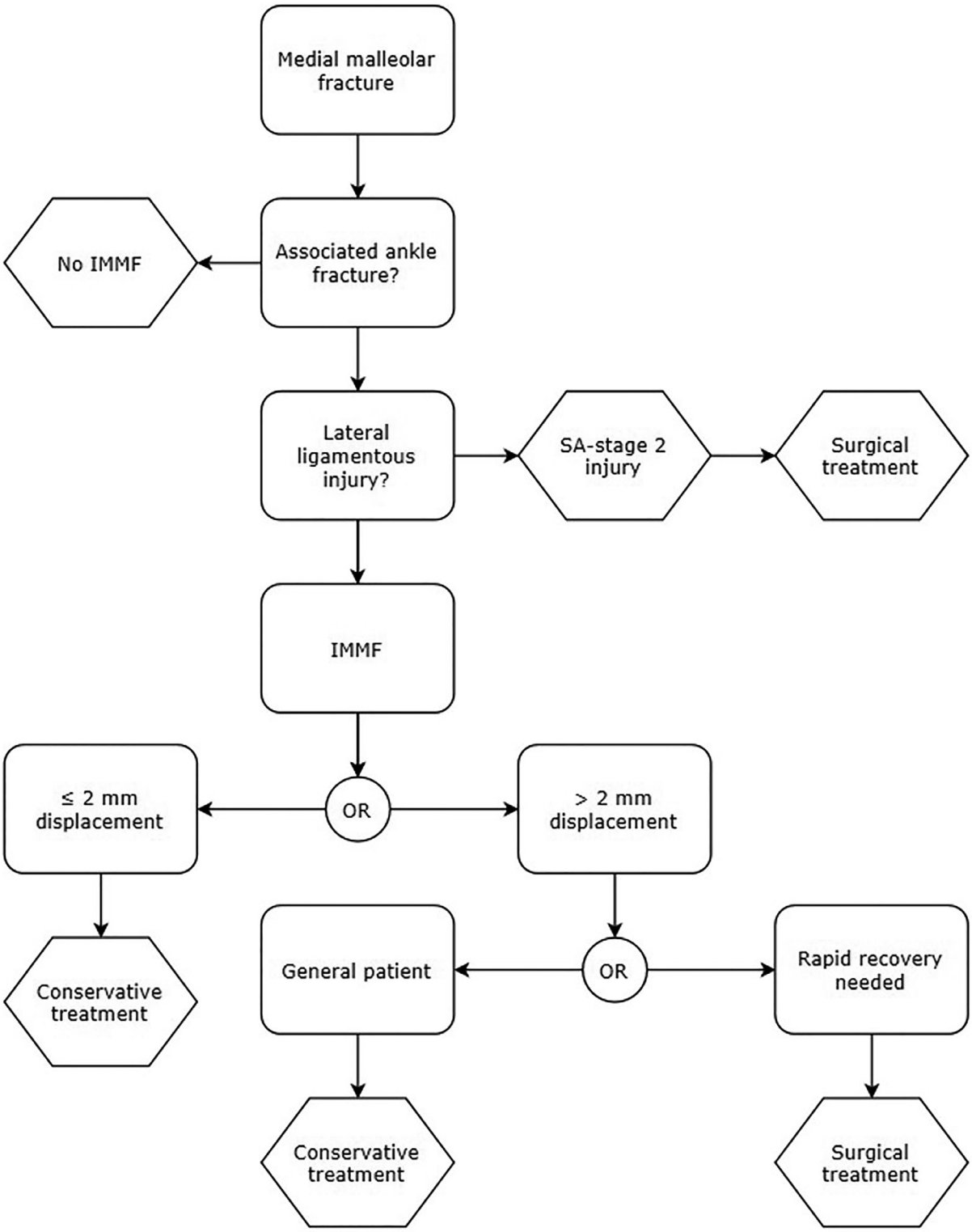

Figure 2. Suggested flowchart. Abbreviations: IMMF, isolated medial malleolar fracture; SA, supination-adduction.

might be a slightly increased risk of nonunion after conservative treatment. Therefore, the choice for surgical or conservative treatment for IMMFs displaced >2 mm might be mainly dependent on the patients' characteristics and demands.

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1053/j.jfas.2018.12.028.

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