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Review

Surgical versus conservative treatment for ankle fractures in adults – A systematic review and meta-analysis of the benefits and harms

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ABSTRACT

Introduction: Despite fractures of the ankle being very common, there is a lack of clarity regarding the relative effectiveness of conservative versus surgical treatment.
The purpose of this systematic review and meta-analysis was to investigate the clinical effects, benefits, and harms of surgical versus conservative treatment of ankle fractures in adults.
Methods: A systematic search strategy was conducted in the databases: Pubmed, Embase, Web of Science, and Cochrane up until the 16th of August 2017. Eight available randomized controlled trials, regardless of fracture type, reported on patient-reported ankle-specific functional outcome and were included. Analyses were based on random effects models.
Results: The 8 included studies randomly allocated 1237 patients to either surgical or conservative treatment. Mean age of patients ranged from 38.1 to 71.4 years. Five studies evaluated short-term patient-reported ankle function, with no significant difference between surgery and conservative treatment (SMD = −0.14, 95%CI = −0.57 to 0.29, $P = 0.51$, $I^2 = 84\%$). Three studies evaluated health-related quality of life, with no significant difference in treatment effect between surgery or conservative treatment (SMD = 0.13, 95%CI = −0.01 to 0.27, $P = 0.06$, $I^2 = 0\%$).
Conclusions: The best available current evidence supports that clinicians can manage ankle fractures by both surgical and conservative means with equal short-term results in selected patient groups with stable and unstable nondisplaced ankle fractures. However, more research is needed including high-quality RCTs investigating the long-term effects. This is especially the case in younger patients, before making significant interpretations about clinical practice.

Contents

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1. Introduction

Ankle fractures are often the result of a fall from a standing height or from participating in sports [1]. These fractures are common and represent one out of every 10 bone injuries with an overall incidence of 169 per 100,000 person-years [1,2]. During the past decades, the number of ankle fractures has increased steadily which is thought to be caused by an increase in the number of people participating in sports and a shift in demographics toward an elderly population [2–4].

The patients who most commonly sustain ankle fractures are between 41 and 49 years old, and the highest incidence is observed among younger males and older females [1,2,4]. The primary goal when treating ankle fractures is to restore normal function of the ankle joint. Both surgical and conservative (non-surgical) treatment can be used to restore normal function in selected patient groups [5,6]. Surgical treatment involves repositioning and surgical fixation of the fracture with screws, plates, or pins. The aim is to provide anatomical restoration and stability of the fractured bones and facilitate early mobilization.

Both surgical and conservative treatment options are associated with risk of complications [6]. Both conservative and surgical treatment involves immobilization for several weeks and may lead to muscle atrophy, stiffness, and swelling of the ankle joint and cartilage degeneration [6]. Moreover, increased risk of malalignment, nonunion, and prolonged immobilization are all complications reported in connection with conservative treatment [6,7]. Surgical interventions are associated with the risk of infection, deep vein thrombosis, reoperation, failure of hardware, amputation, and mortality [6,8].

Despite fractures of the ankle being very common, consensus regarding treatment with surgery or by conservative means lacks evidence in patients with nondisplaced unstable ankle fractures. The latest Cochrane review from 2012 concluded there is insufficient evidence to conclude on the effects of surgical versus conservative treatment of ankle fractures in adults [6]. Since that review, multiple large randomized trials have been conducted, and an updated review to guide clinical practice is needed.

The purpose of this systematic review and meta-analysis was to investigate the clinical effects, benefits, and harms of surgical versus conservative treatment of ankle fractures in adults.

2. Methods

The design for this systematic review was developed using the PRISMA-P statement, and the review is reported following the PRISMA statement [9]. This review was registered in PROSPERO (ID: 42017059395), and the full study protocol was published online at the time of registration [10,11].

The literature review was performed based on a systematic search in the following bibliographic databases: Medline via Pubmed, Embase, Web of Science, and Cochrane Central Register of Controlled Trials. The search strategy was developed using the previous Cochrane systematic review and conducted by a research librarian to ensure a complete and transparent search [6]. The review includes all available randomized trials up to August 16, 2017. A hand-search of reference lists of relevant articles was also conducted for other potential relevant references. Only trials written in English were included.

2.1. Study selection

This study included randomized trials comparing surgical and conservative treatment of ankle fractures in adults. All included studies had to fulfill the following criteria: (1) a full-text English-language paper published in a peer-reviewed journal, (2) contain original data from a randomized or a cluster randomized trial, (3) compare surgical and conservative treatment interventions following an ankle fracture, and (4) investigate patient-reported outcomes and/or functional outcomes and/or radiological outcomes.

Two authors (PL and RE) independently performed the selection of studies based on the full references and abstract screening. A full-text evaluation of the selected studies followed this. Disagreement between the two reviewers was solved by consensus or by the inclusion of a third reviewer (MSR).

2.2. Data extraction and risk of bias

Two independent reviewers (PL and RE) extracted data using a specifically designed standardized data extracting form. After data extraction, the independent reviewers checked for consistency between the extracted data. All inconsistencies between the two forms were resolved by discussion between the two data extractors and checking with the original publication. Any disagreement between the data extractors after the initial discussion was solved by involving a third person (MSR).

General study information, participants and intervention characteristics, compliance, adverse events, withdrawals, and outcome measures were extracted. Whenever possible, results from the intention-to-treat population were used.

Included randomized studies were assessed for risk of bias by two independent reviewers (PL and RE) using the Cochrane Collaboration's tool for assessing risk of bias in randomized trials [12]. Each trial was evaluated across seven domains of bias. The risk of bias assessment was classified as high, low, or unclear.

2.3. Primary outcome

The primary outcome measurement was ankle specific function scores reported with a minimum of six-month follow-up and a maximum of three years, defined as short-term functional outcome. Endpoints shorter than six months and longer than 10 years were also collected and reported, but the short-term functional outcome was considered primary.

Functional outcome scores may include (but are not limited to) Olerud–Molander score, Foot and Ankle Outcome Score (FAOS), and Lower Extremity Functional Scale, prioritized in this order.

2.4. Secondary outcome

Secondary outcomes include general health questionnaires, which include (but are not limited to): instruments such as SF-36, SF-12, and EQ5D, prioritized in this order. Other secondary outcomes include pain scores, major adverse events and radiological outcomes including development of osteoarthritis and joint congruency. Secondary outcomes include both short-term outcomes defined as between six months and three years follow-up and long-term outcomes defined as three to 10 years follow-up.

3. Data synthesis and analyses

3.1. Primary analysis

The primary analysis compares the functional outcomes between surgical and conservative treatment of ankle fractures in adults. Difference between groups was expressed as the standardized mean difference (SMD). The SMD was estimated individually for all included trials. The SMD was estimated as the mean difference between surgical intervention and conservative treatment divided by the pooled standard deviations (SD). If the SD was not available, it was estimated from the standard error (SE) or confidence interval (CI) as recommended by the *Cochrane Handbook for Systematic Reviews of Interventions* [12]. Data from the trials were pooled as appropriate using a random-effects model.

3.2. Secondary analyses

The secondary analyses included a comparison between surgical and conservative treatment of ankle fractures on general health questionnaire, pain, adverse events, and radiological outcomes. All continuous variables were expressed as SMD between surgical and conservative interventions. Binary outcomes for each trial were expressed as odds ratios and 95% confidence intervals. If possible, data from the trials were pooled as appropriate using a random-effects model.

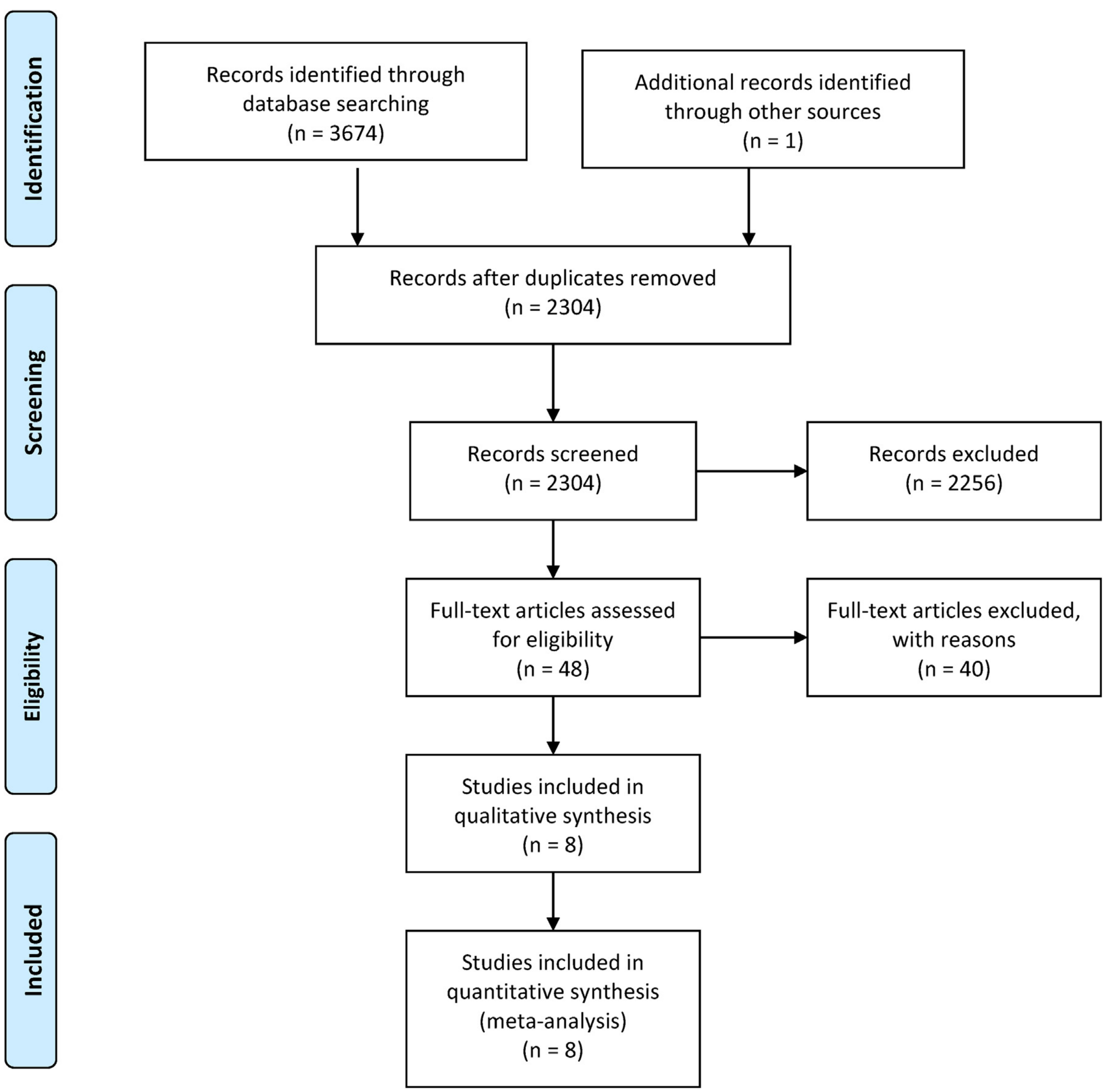

Fig. 1. Flow of study inclusion. n = number.

3.3. Predefined subgroup analyses

A subgroup analysis explored the risk of major adverse events after surgical and conservative treatment, including infection, deep vein thrombosis, delayed- or malunion, death, unplanned surgery, neurovascular injury, removal of internal fixation and other adverse events deemed of clinical importance.

All analyses used RevMan, version 4.2 (Wintertree Software Inc., Oxford, United Kingdom) software.

4. Results

The literature search included 2304 studies after removal of duplicates. After review of title and abstract, 48 studies were selected for full-text review. Following the full-text review, 40 studies were excluded, leaving eight studies [5,7,13–18] comparing conservative and surgical treatments of patients with ankle fracture in an RCT (randomized controlled trial) design (Fig. 1).

4.1. Study characteristics

The eight included studies randomly allocated 1237 patients to either surgical or conservative treatment. The mean age of patients ranges from 38.1 to 71.4 years. The mean follow-up time ranged from five months to 84 months (Table 1).

4.2. Risk of bias

The assessment of risk of bias showed high risk of bias in several of the included studies. No studies were double-blinded, and the outcome assessor was blinded in only two studies [7,13]. Cross-over for surgical treatment is frequently reported; however, only three studies clearly state the use of intention-to-treat analysis [5,7,13]. Moreover, randomization procedure or concealment of allocation was unclear in seven studies [5,14,16–19].

4.3. Primary analysis of short-term functional patient-reported outcome

Five studies evaluated the primary outcome [7,13–16], short-term functional patient-reported outcome. Three studies reported the outcome using the OMAS score, one study used the FAOQ score, and one study used the American Orthopedic Foot and Ankle Society (AOFAS) score.

Data from the three studies reporting the OMAS score were successfully pooled, and groups were homogeneous. The data analysis revealed no significant difference in treatment effect between surgery or conservative treatment (standard mean difference = 0.14, 95%CI = −0.09 to 0.38, P = 0.24, I^2 = 25% (Fig. 2).

Data from all five studies that evaluated the short-term functional patient-reported outcome were pooled and showed substantial heterogeneity and no significant difference in treatment effect between surgery or conservative treatment (standard mean difference = −0.14, 95%CI = −0.57 to 0.29, P = 0.51, I^2 = 84% (Fig. 2).

4.4. Secondary outcomes

4.4.1. Short-term patient-reported HRQOL

The short-term patient-reported HRQOL was reported in three studies [7,13,15]. Data from the three studies were pooled. The analysis showed no significant difference in HRQOL between surgery or conservative treatment (standard mean difference = 0.13, 95%CI = −0.01 to 0.27, P = 0.06, I^2 = 0%) (Fig. 3).

4.4.2. Long-term functional patient-reported outcome and QOL

Long-term outcomes were reported in two studies [5,17] with a follow-up time of 42 months and 84 months, respectively. Both studies used non-validated outcome measurements and the data could not be pooled because they were provided in different measurement scales. Phillips et al. [17] showed a significant difference in QOL between surgery or conservative treatment, favoring conservative treatment (standard mean difference = 2.97, 95%CI = 2.14–3.81, $P < 0.01$). Bauer et al. [5] showed no significant difference in QOL between surgery and conservative treatment (risk ratio = 0.90, 95%CI = 0.46–1.76, P = 0.75).

4.4.3. Pain

Four studies evaluated pain symptoms [5,7,14,16]. Data from three studies evaluated short-term pain outcome and were pooled. The analysis showed no significant difference in short-term pain outcome between surgery or conservative treatment and considerable heterogeneity (standard mean difference = −0.40, 95%CI = −1.20 to 0.40, P = 0.32, I^2 = 87%). Bauer et al. [5] was assessed separately and reported the long-term outcome and used a dichotomy outcome measurement for pain assessment. The study showed no significant difference in pain between surgery or conservative treatment (risk ratio = 1.06, 95%CI = 0.56–2.0, P = 0.86) (Fig. 4).

Table 1
Study characteristics.

Study	Population	Mean age	Follow-up	Primary outcome	Randomized	Analyzed
Willet et al. (2016)	620	71 (SD7.3)	6 months	OMAS	Surgery = 309 Conservative = 311	Surgery = 291 Conservative = 267
Mittal et al. (2017)	160	39 (SD13.4)	12 months	FAOQ	Surgery = 80 Conservative = 80	Surgery = 71 Conservative = 68
Sanders et al. (2012)	81	41 (18–85 years)	12 months	OMAS SF-36	Surgery = 41 Conservative = 40	Not disclosed
Philips et al. (1985)	96	43 (15–78 years)	42 months	Self-developed	Not disclosed	Surgery = 23 Conservative = 26
Salai et al. (2000)	84	78 (65–91 years)	38 months	AOFAS	Surgery = 19 Conservative = 16	Surgery = 49 Conservative = 16
Makwana et al. (2001)	43	66 (55–81 years)	27 months	OMAS	Surgery = 22 Conservative = 21	Surgery = 19 Conservative = 12
Bauer et al. (1985)	111	44 (16–77 years)	84 months	Self-developed	Surgery = 51 Conservative = 57	Surgery = 44 Conservative = 56
Rowley et al. (1986)	42	(16–70 years)	5 months	Time to weight-bearing	Surgery = 20 Conservative = 22	Surgery = 20 Conservative = 20

OMAS (Olerud–Molander Ankle Score), FAOQ (American Academy of Orthopaedic Surgeons Foot and Ankle Outcomes Questionnaire), SF36, Short-form 36 (6-Item Short Form Health Survey), AOFAS (American Orthopaedic Foot and Ankle Society score).

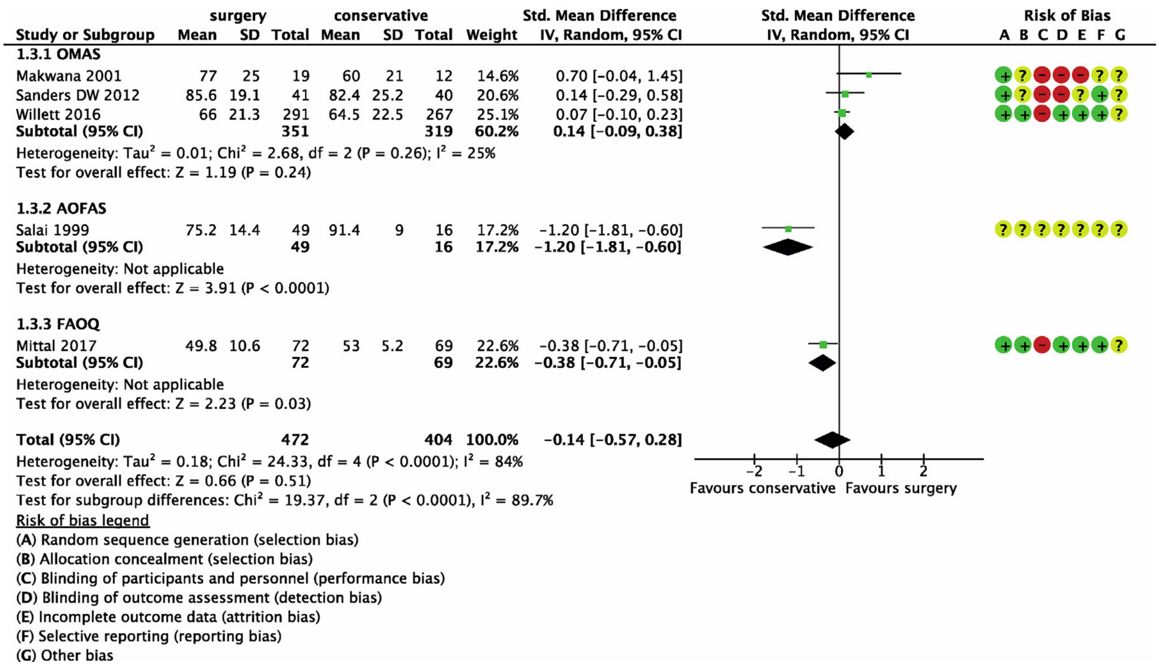

Fig. 2. Short-term functional patient-reported outcome.

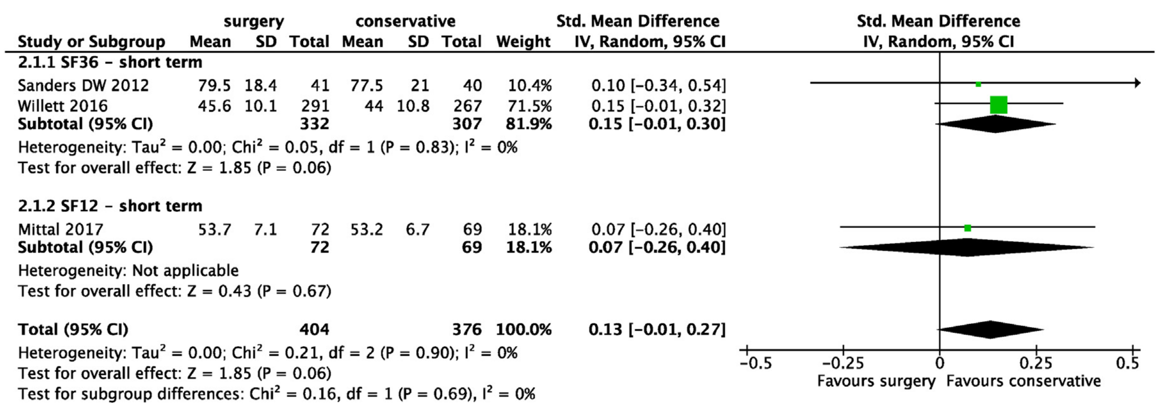

Fig. 3. Short-term HRQOL (health-related quality of life).

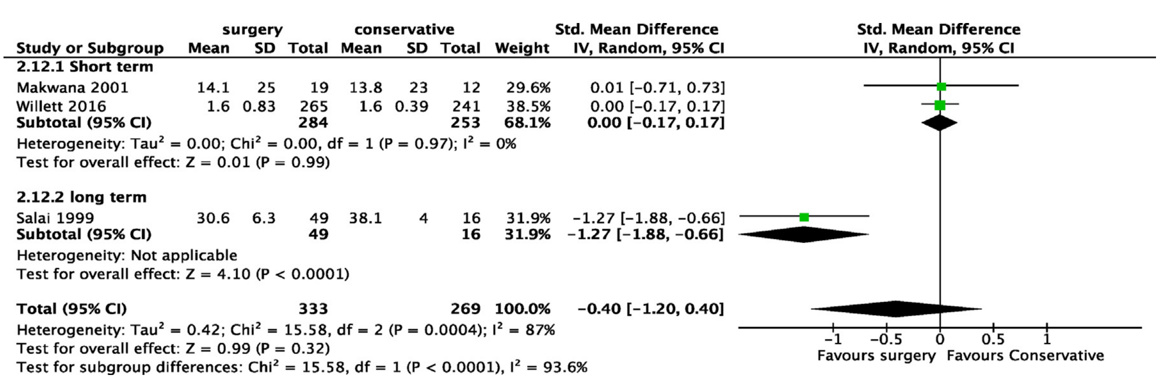

Fig. 4. Pain outcome.

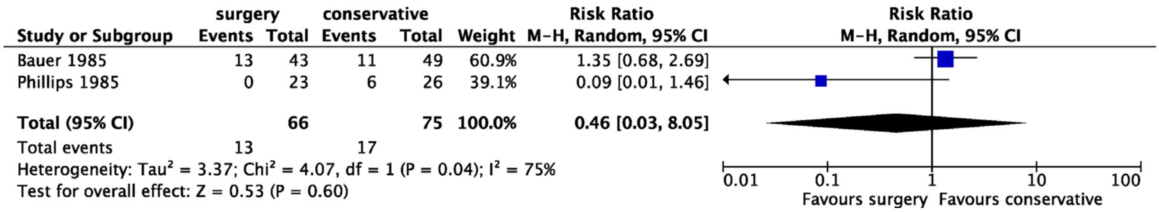

Fig. 5. Osteoarthritis outcome (long-term).

4.4.4. Range of motion (ROM)

Four studies reported on the ROM. However, all used different measurement methods, and as a consequence, no data pooling was possible [5,7,14,18]. Makwana et al. [14] showed a statistically significant difference between conservative and operative treatment favoring surgery. The remaining studies did not report a significant difference between groups [5,7,18].

4.4.5. Osteoarthritis

Outcome regarding the development of osteoarthritis was reported in two studies [5,17]. Data from the two studies were pooled, and the analysis showed no significant difference in the development of osteoarthritis between surgery or conservative treatment groups and considerable heterogeneity (standard mean difference = 0.46, 95%CI = 0.03–8.05, P = 0.60, I^2 = 75%) (Fig. 5).

4.4.6. Adverse events

Data regarding adverse events and complications were reported in all included studies. Data from all studies were divided into nine different categories of adverse events. Two of the nine categories showed significant difference and heterogeneous data in effect between surgery and conservative treatment. Delayed or malunion favored surgery treatment (risk ratio = 0.08, 95%CI = 0.01–0.96, P = 0.02, I^2 = 0%). Removal of internal fixation favored conservative treatment (risk ratio = 6.03, 95%CI = 1.99–18.29, P = 0.001, I^2 = 0%) (Fig. 6).

5. Discussion

Based on the best available evidence, this systematic review and meta-analyses suggest that short-term functional patient-reported outcome after surgical or conservative treatment of nondisplaced unstable ankle fractures are comparable in a highly selected patient group. Moreover, no significant difference between surgical and conservative treatment was found with regard to HRQOL, pain, or development of osteoarthritis. However, the results of this systematic review and meta-analyses should be interpreted with caution as several limitations exist in the available studies including a lack of long-term follow-up studies among younger patient groups and a high degree of selection of included patients in several of the studies. This systematic review included a total of 1237 patients compared to the last Cochrane review published in 2012 [6] including 296 patients.

The latest Cochrane review from 2012 concluded there is insufficient evidence to conclude on the effects of surgical versus conservative treatment of ankle fractures in adults [6]. The results on the present study strengthen the notion that selected patient groups might have equal short-term patient-reported outcome when managed by either conservative means or by surgery. Furthermore, several high quality studies have been conducted in the last years [7,13], increasing the quality of evidence.

Five studies evaluated the primary outcome [7,13–16], short-term functional patient-reported outcome. The five studies used three different outcome measurements with considerable variation in follow-up time, representing an important limitation and a possible explanation for the high degree of heterogeneity in the meta-analyses. However, data from the three studies reporting the OMAS score were successfully pooled, and the data were homogeneous. The meta-analyses revealed no significant difference in treatment effect between surgery and conservative treatment.

The short-term patient-reported HRQOL was reported in three studies [7,13,15]. Data were homogeneous and showed no significant difference in treatment effect between surgery or conservative treatment.

This systematic review included studies comparing a large variation of different ankle fracture patterns ranging from simple lateral malleolar fractures without talar shift to more complex ankle fractures where “satisfactory” initial closed reduction was achieved and maintained in a cast. The studies included in this systematic review represent a selected group of patients, where satisfactory initial closed reduction was possible in all patients, which may exclude some of the more complex fractures. Furthermore, differentiation between the different patterns of ankle fractures included was not possible, due to difference in classification methods between the studies, and consequently, subgroup analyses were not possible in this systematic review. This inevitably limits the possibility to make firm clinical conclusions.

The follow-up times of the included studies range from 5 to 84 months and include many different outcome measurements, representing another important limitation. The incidence of ankle fractures is described with a peak incidence among adolescents in both genders and with increasing incidence for females throughout life [1]. As a consequence of a high incidence of fractures in younger patients, studies with long-term follow-up are needed. This systematic review included only two studies with long-term follow-up reporting conflicting results regarding functional outcomes [5,17]. The development of osteoarthritis was also reported in the two studies suggesting no significant difference between surgery and conservative treatment [5,17]. However, the analyses showed high degrees of heterogeneity, and considering the low number of patients included for analyses, the studies may lack the power to establish any evidence regarding development of osteoarthritis. Surgical treatment of ankle fractures may lead to more accurate anatomical reduction compared to conservative treatment [20]. Several studies suggested that a lack of reduction may lead to an increased risk of posttraumatic osteoarthritis [17,20]; however, other studies could not demonstrate this association [21]. More research including high-quality RCTs with long-term follow-up is needed to understand the effect of conservative and surgical treatment of ankle fractures, especially in the younger patient groups with regards to difference in the development of posttraumatic osteoarthritis.

Four studies evaluated pain symptoms following ankle fractures [5,7,14,16]. The analyses showed no significant difference in short-term outcome between surgical and conservative

Study or Subgroup	surgery Events	surgery Total	conservative Events	conservative Total	Weight	Risk Ratio M-H, Random, 95% CI
2.5.1 Superficial infection						
Bauer 1985	2	51	2	57	9.3%	1.12 [0.16, 7.65]
Makwana 2001	1	19	1	12	5.1%	0.63 [0.04, 9.17]
Mittal 2017	11	73	1	72	8.5%	10.85 [1.44, 81.87]
Phillips 1985	1	23	2	26	6.6%	0.57 [0.05, 5.83]
Salai 1999	2	40	0	16	4.2%	2.07 [0.10, 40.95]
Sanders DW 2012	5	41	0	40	4.5%	10.74 [0.61, 188.05]
Willett 2016	60	298	37	275	61.8%	1.50 [1.03, 2.18]
Subtotal (95% CI)		**545**		**498**	**100.0%**	**1.71 [0.92, 3.20]**
Total events	82		43			
Heterogeneity: Tau² = 0.13; Chi² = 6.97, df = 6 (P = 0.32); I² = 14%						
Test for overall effect: Z = 1.69 (P = 0.09)						
2.5.2 Deep infection						
Bauer 1985	0	51	2	57	34.3%	0.22 [0.01, 4.54]
Mittal 2017	2	73	0	72	34.2%	4.93 [0.24, 100.98]
Sanders DW 2012	1	41	0	40	31.4%	2.93 [0.12, 69.83]
Subtotal (95% CI)		**165**		**169**	**100.0%**	**1.45 [0.22, 9.69]**
Total events	3		2			
Heterogeneity: Tau² = 0.38; Chi² = 2.31, df = 2 (P = 0.32); I² = 13%						
Test for overall effect: Z = 0.38 (P = 0.70)						
2.5.3 DVT						
Bauer 1985	2	51	3	57	24.9%	0.75 [0.13, 4.28]
Mittal 2017	5	73	3	72	33.2%	1.64 [0.41, 6.63]
Willett 2016	4	298	12	275	41.8%	0.31 [0.10, 0.94]
Subtotal (95% CI)		**422**		**404**	**100.0%**	**0.67 [0.23, 1.92]**
Total events	11		18			
Heterogeneity: Tau² = 0.37; Chi² = 3.44, df = 2 (P = 0.18); I² = 42%						
Test for overall effect: Z = 0.75 (P = 0.46)						
2.5.4 Delayed og malunion						
Makwana 2001	0	19	2	12	47.7%	0.13 [0.01, 2.50]
Sanders DW 2012	0	41	8	40	52.3%	0.06 [0.00, 0.96]
Subtotal (95% CI)		**60**		**52**	**100.0%**	**0.08 [0.01, 0.65]**
Total events	0		10			
Heterogeneity: Tau² = 0.00; Chi² = 0.16, df = 1 (P = 0.69); I² = 0%						
Test for overall effect: Z = 2.37 (P = 0.02)						
2.5.5 shift of treatment						
Bauer 1985	0	51	4	57	13.7%	0.12 [0.01, 2.25]
Makwana 2001	0	19	8	21	14.1%	0.06 [0.00, 1.05]
Mittal 2017	8	73	2	72	17.8%	3.95 [0.87, 17.95]
Phillips 1985	0	23	1	26	13.0%	0.38 [0.02, 8.78]
Rowley 1986	0	20	2	22	13.5%	0.22 [0.01, 4.30]
Salai 1999	0	16	4	19	13.9%	0.13 [0.01, 2.26]
Willett 2016	0	291	52	275	14.1%	0.01 [0.00, 0.15]
Subtotal (95% CI)		**493**		**492**	**100.0%**	**0.18 [0.03, 1.24]**
Total events	8		73			
Heterogeneity: Tau² = 4.82; Chi² = 22.86, df = 6 (P = 0.0008); I² = 74%						
Test for overall effect: Z = 1.74 (P = 0.08)						
2.5.6 Death as result of treatment						
Bauer 1985	0	51	1	57	100.0%	0.37 [0.02, 8.93]
Subtotal (95% CI)		**51**		**57**	**100.0%**	**0.37 [0.02, 8.93]**
Total events	0		1			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.61 (P = 0.54)						
2.5.7 Unplanned sugery						
Bauer 1985	0	51	4	57	13.7%	0.12 [0.01, 2.25]
Makwana 2001	0	19	8	21	14.2%	0.06 [0.00, 1.05]
Mittal 2017	7	73	2	72	21.1%	3.45 [0.74, 16.06]
Phillips 1985	0	23	1	26	12.5%	0.38 [0.02, 8.78]
Rowley 1986	0	20	2	22	13.3%	0.22 [0.01, 4.30]
Willett 2016	7	298	63	275	25.2%	0.10 [0.05, 0.22]
Subtotal (95% CI)		**484**		**473**	**100.0%**	**0.27 [0.06, 1.25]**
Total events	14		80			
Heterogeneity: Tau² = 2.27; Chi² = 17.02, df = 5 (P = 0.004); I² = 71%						
Test for overall effect: Z = 1.68 (P = 0.09)						
2.5.8 Neurovaskular injury						
Mittal 2017	5	73	2	72	49.5%	2.47 [0.49, 12.30]
Willett 2016	3	298	3	275	50.5%	0.92 [0.19, 4.53]
Subtotal (95% CI)		**371**		**347**	**100.0%**	**1.50 [0.48, 4.65]**
Total events	8		5			
Heterogeneity: Tau² = 0.00; Chi² = 0.73, df = 1 (P = 0.39); I² = 0%						
Test for overall effect: Z = 0.70 (P = 0.48)						
2.5.9 Other						
Bauer 1985	0	51	1	57	46.3%	0.37 [0.02, 8.93]
Makwana 2001	3	19	0	12	53.7%	4.55 [0.26, 81.03]
Subtotal (95% CI)		**70**		**69**	**100.0%**	**1.43 [0.12, 16.63]**
Total events	3		1			
Heterogeneity: Tau² = 0.76; Chi² = 1.32, df = 1 (P = 0.25); I² = 24%						
Test for overall effect: Z = 0.28 (P = 0.78)						
2.5.10 Removal of internal fixation						
Makwana 2001	3	19	0	12	14.8%	4.55 [0.26, 81.03]
Salai 1999	16	49	0	16	16.2%	11.22 [0.71, 177.12]
Sanders DW 2012	5	41	0	40	15.0%	10.74 [0.61, 188.05]
Willett 2016	10	298	2	275	54.0%	4.61 [1.02, 20.87]
Subtotal (95% CI)		**407**		**343**	**100.0%**	**6.03 [1.99, 18.29]**
Total events	34		2			
Heterogeneity: Tau² = 0.00; Chi² = 0.54, df = 3 (P = 0.91); I² = 0%						
Test for overall effect: Z = 3.18 (P = 0.001)						

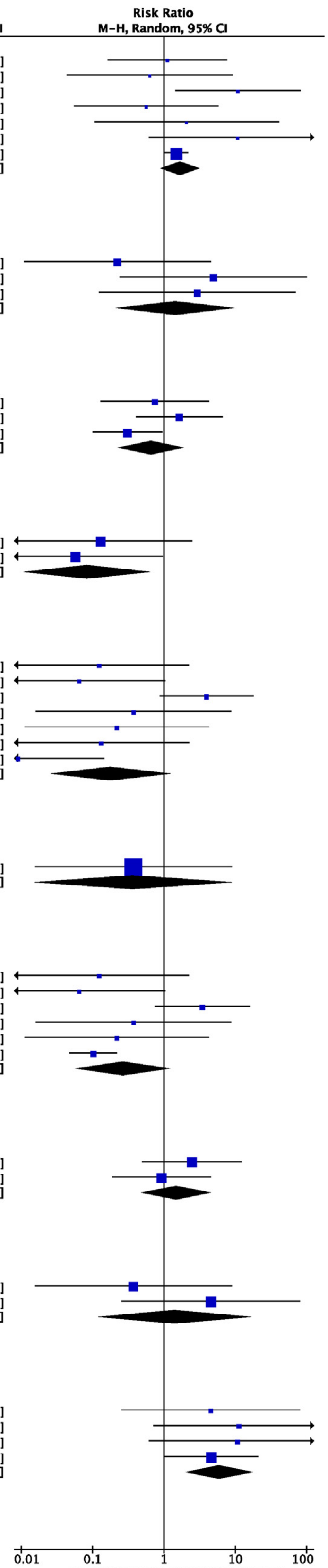

Fig. 6. Adverse events.

treatment. However, the meta-analyses showed considerable heterogeneity. Different patient groups, follow-up times, and methodological quality between studies may explain this. Comparing the two most recent studies, both with a high degree of methodical quality, the analyses showed that groups were homogeneous and no significant difference in pain between surgery and conservative treatment was observed. Moreover, Bauer et al. [5] reported the long-term outcome of pain and showed no significant difference in pain between surgery and conservative treatment.

The age of patients included in the studies range from 15 to 91 years, representing an important limitation to this systematic review. In the authors' opinion, two major concerns regarding patients' age need to be addressed. Firstly, long-term effect of the treatment modalities need to be investigated in the younger patient groups, and currently no high-quality RCTs address this important issue. Secondly, older patients may present with different fracture etiology and with considerable comorbidity, which is known to influence the outcome of treatment including bone healing, infection, and other adverse events, which is likely to affect the outcome of both surgery and conservative treatment [22]. Furthermore, prolonged periods of immobilization in the older patients may influence the ability to regain the activity of daily living. However, subgroup analyses of different age groups were not possible in this systematic review due to the low number of available studies and more research is needed to understand the influence of age on outcome with regard to both conservative and surgical treatment of ankle fractures.

With regard to adverse events, only delayed union or malunion and removal of internal fixation showed a significant difference between the surgical and conservative groups. However, some clinically important differences between groups should be addressed. Obviously, shift of treatment favors the surgery group, as only patients in the conservative group had this option. Shift of treatment accounts for roughly 15% in the conservative group, primarily as a result of a loss of reduction at early follow-up. Moreover, obviously, removal of internal fixation favors the conservative group. Eight percent of patients had internal fixation hardware removed. This systematic review lacks high-quality RCTs with long-term follow-up, and this information may, therefore, be limited as the incidence of hardware removal would be expected to increase with time. In general, a low number of adverse events were observed in both the conservative and surgical groups, suggesting that both conservative and surgical treatment of ankle fractures are safe and equal in a selected group of patients.

5.1. Strength and limitations

The strength of this systematic review is the use of a standardized method during all steps of the study procedure. The use of two assessors in study selection, data extraction, and assessment of risk of bias is a major strength. Only minor differences between assessors were observed during the study procedure. Minor disagreements were related to reading errors. Moreover, a strength was the final literature search performed immediately before publication, ensuring all available literature was included.

However, some limitations should be addressed. Substantial heterogeneity was observed in both primary and secondary outcomes, and consequently, conclusions from this systematic review and meta-analysis may be limited. Due to the low number of studies included in the meta-analysis, a statistical test (funnel plots) for publication bias was not used. Methodological literature recommended at least 10 studies to be included in meta-analysis to perform statistical tests [12]. Moreover, the assessment of risk of bias showed several studies presented with methodological limitations. However, other studies included in the analysis had a high methodological quality score. Due to the nature of the studies, blinding of participants and physicians is very difficult and was not performed in any of the studies. Nonetheless, the high risk of bias for some of the included studies may limit the conclusion, and interpretation should be viewed with caution.

6. Conclusion

The best available current evidence supports that clinicians can manage ankle fractures by both surgical and conservative means with equal short-term results in selected patient groups with stable and unstable nondisplaced ankle fractures. However, more research is needed including high-quality RCTs investigating the long-term effects. This is especially the case in younger patients, before making significant interpretations about clinical practice.

Conflict of interest

None declared.

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