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Characteristics and effectiveness of postoperative rehabilitation strategies in ankle fractures: a systematic review

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ABSTRACT

Objectives: To explore the characteristics and (2) to report on the effectiveness of postoperative rehabilitation strategies for people with an ankle fracture. **Data Sources:** PubMed, Cochrane Library, EMBASE, Web of Science and CINAHL to identify studies published from January 2010 to November 2021.

Study selection: Studies that described or evaluated postoperative rehabilitation strategies for surgically repaired ankle fractures.

Data extraction: Data on postoperative rehabilitation were extracted in accordance with the Template for Intervention Description and Replication (TIDieR) guide. Quality was assessed using the National Heart, Lung and Blood Institute's Study Quality Assessment Tools.

Data synthesis: Meta-analysis was planned to look at the effectiveness of postoperative rehabilitation strategies. Forty studies described postoperative rehabilitation strategies without evaluating effectiveness while 15 studies focused on evaluating effectiveness. Due to the large variety in postoperative strategies and outcomes, narrative synthesis was deemed most suitable to answer our aims. Characteristics of postoperative rehabilitation strategies varied widely and were poorly described in a way that could not be replicated. Most of the studies (48%) utilised a late weight-bearing approach although definitions and details around weight-bearing were unclear.

Conclusions: Late weight-bearing has been the most common postoperative approach reported in the past 10 years. The variety of definitions around weight-bearing and the lack of details of rehabilitation regimes limits replication and impacts current clinical practice. Authors propose to adopt consistent definitions and terminology around postoperative practices like weight-bearing to improve evidence for effectiveness and ultimately patient outcomes.

Level of evidence: Level III. See Instructions for Authors for a complete description of levels of evidence.

KEY WORDS: Ankle fracture, weightbearing, weight bearing, post-operative rehabilitation, physiotherapy

INTRODUCTION

While ankle fractures are common and costly worldwide,[1,2] postsurgical rehabilitation interventions for these injuries vary, adding to the fragmented communication around rehabilitation between treating clinicians and patients.[3,4] Several systematic reviews have focused on the effectiveness of different postsurgical rehabilitation strategies and protocols for ankle fractures.[5-13] While some reviews have concluded that there is limited evidence for using a removable type of immobilisation (i.e. orthoses) with early weight-bearing and mobilisation,[9,10,12,13] others have stated that early weight-bearing and mobilisation can accelerate a return to daily activities and work,[8,11] especially for the young and fit patient.[7] Furthermore, a Cochrane systematic review concluded that there is no evidence of efficacy for stretching, manual therapy or exercise compared to usual care following a period of immobilisation.[10] A survey of physicians found limited consensus for non-weight-bearing

times after ankle fractures ranging from 4.9 to 7.6 weeks on average, depending on patient characteristics.[14] This leaves both patients and rehabilitation providers unsure of the optimal postsurgical management for ankle fractures.

The two most recent systematic reviews and meta-analyses on postoperative recommendations in ankle fractures were published in 2015 and 2021. These systematic reviews investigated specified types of postoperative strategies; the 2021 review reported no difference in outcomes between *early and late weight-bearing*,[13] while the 2015 review reported better outcomes for those performing *ankle exercises compared to immobilization*.[11] Findings for complication rate also varied, with the 2021 review reporting increased complications after early ankle mobilisation, while the 2015 review reporting no differences between early and late weight-bearing.[11,13] These reviews focused on the *effect* of specific postoperative strategies on patient outcomes, but did not detail the range of postoperative strategies available, nor offer details on interventions such as the exact timing and percentage/amount of weight-bearing, use of mobility aids, or other therapy modalities that can influence patient outcomes and inform clinical decision making. Thus, a comprehensive review that described the current postoperative practices by detailing the specific characteristics of published current ankle postoperative rehabilitation strategies, and their effectiveness is needed.

The research questions for this review were:

1. To explore the characteristics of postoperative rehabilitation strategies for people with an ankle fracture in peer-reviewed papers published from 1 January 2010 to 1 November 2021.

2. To report on the effectiveness of postoperative rehabilitation strategies for people with an ankle fracture in peer-reviewed papers published from 1 January 2010 to 1 November 2021.

MATERIALS AND METHODS

Search strategy

This systematic review was performed according to the PRISMA guidelines for reporting systematic reviews,[15] and registered at the international prospective register of systematic reviews (PROSPERO).[16] An electronic search was performed in PubMed, Cochrane Library, EMBASE, Web of Science and CINAHL to identify studies that met the inclusion criteria, published in English, in the past 10 years. The electronic search used the following phrases as MeSH and/or text words until 1 November 2021: 'postoperative care', 'rehabilitation', 'mobilization', 'weight-bearing', 'ankle fractures''. The specific search terms in for each database can be found in an Appendix, see Supplemental Digital Content 1, http://links.lww.com/JOT/B764.

Study selection

After the electronic search, duplicates were removed, titles and abstracts were screened by two of three researchers (MP, SM, VM) and conflicts resolved by a fourth researcher (NA). Full-text articles were retrieved and assessed for eligibility. Each manuscript was screened by two of three researchers and conflicts resolved by consensus (MP, SM and VM). Disagreements were resolved through consultation with an independent author not involved in other aspects of screening (VJ). To be included, studies had to describe and/or evaluate one or more postoperative rehabilitation strategies for surgically repaired ankle fractures published between 1 January 2010 to 1 November 2021 (detailed eligibility see Table 1). Review articles, studies published in a language other than English and studies for which full text was not available were excluded. Reference lists of all included papers were screened to detect studies not identified by the electronic search.

Methodological quality assessment

Quality of the included studies was assessed using the National Heart, Lung and Blood Institute's Study Quality Assessment Tools.[17] The quality of each paper was assessed by one reviewer, with a sample reviewed by an additional reviewer to check for agreement. Disagreements were resolved by consensus by all reviewers. No studies were excluded based on quality because we were interested in the types of rehabilitation protocols described across all studies, not quality of evidence from individual studies.

Data extraction

Data were extracted by three authors (MP, SM, VM). Data extraction forms were developed prior to data extraction. Data on sample size, diagnostic criteria, population characteristics (age, sex, BMI), the type of ankle fractures, the surgical technique and postoperative rehabilitation were extracted. To better report details of postoperative rehabilitation strategies in ankle fractures, data on postoperative rehabilitation were extracted in accordance with the Template for Intervention Description and Replication (TIDieR) guide.[18] Means, standard deviations (SD), and sample sizes were extracted for all primary outcomes.

Data analysis

Inter-rater reliability for quality assessment items was examined using kappa (κ) statistics (SPSS Version 27.0, IBM Statistics, New York). Reliability was considered as slight (0.00–0.2), fair (0.21–0.4), moderate (0.41–0.6), substantial (0.61–0.8) or almost perfect (0.81–1.0).[19] A narrative synthesis of the results was deemed most suitable to answer the first aim of the review, which was to explore the specific characteristics of postoperative rehabilitation strategies for people with an ankle fracture. Initial findings revealed that a meta-analysis was inappropriate to answer our second aim, due to the large variation in study design and

postoperative rehabilitation strategies. Therefore, a narrative synthesis was also deemed most appropriate.

RESULTS

Study selection

A total of 7,301 articles were identified after a search of databases since 2010 (See Figure 1). After removal of duplicates, and title and abstract screening of 5,843 articles, 181 full-text articles were reviewed. Of these, 55 articles were included (See Figure 1).

Study and participant characteristics

All 55 studies included in the systematic review reported at least one postoperative rehabilitation strategy. Two of these studies used data from the same trial.[20,21] Most studies were prospective cohort studies (n=25, 45%), followed by randomised controlled trials (n=23, 42%), non-randomized controlled studies (n=4, 7%), cross-sectional studies (n=2, 4%) and a case series (n=1, 2%).

The number of participants per study ranged from 10 to 466, with a median of 47 and a mean of 69. Across all studies, the median participant age was 44 (mean 45, range 31 – 58) years, and almost half of the participants were female (1731/3561, 49%).

Quality assessment

Quality scores as rated by 2 authors with the National Heart, Lung and Blood Institute's Study Quality Assessment Tools can be found in an Appendix, see Supplemental Digital

Content 2, http://links.lww.com/JOT/B765. Of all 55 studies, eight were good quality (15%), 21 of fair quality (38%), and 26 of poor quality (47%). Inter-rater agreement for methodological quality was moderate (κ=0.526, p<0.001) with 68/98 agreements.

Across the observational and cross-sectional studies (n=28), most studies clearly defined the research question (n=22, 79%) and the study population (n=25, 89%), and incorporated a timeframe sufficient to see an association between exposure and outcome (n=25, 89%) (see Appendix, Supplemental Digital Content 2, http://links.lww.com/JOT/B765, Table 1). Reporting sample size calculation (n=1, 3%) and assessing the exposure more than once over time (n=1, 3%) contributed to the poor score of several of the included studies.

Across the 27 interventional studies, 26 were controlled intervention studies and one a pre-post study without a control group.[22] Most clearly defined their primary outcome measure (n=25, 96%) and research question (n=20, 77%) but none of the interventional studies recruited from similar populations (see Appendix, Supplemental Digital Content 2, http://links.lww.com/JOT/B765, Table 2).

Characteristics of postoperative rehabilitation strategies

Of all studies, 40 [23-61] described their postoperative rehabilitation strategy but did not evaluate effectiveness and 15[20-22,62-73] focused on evaluating the effectiveness of the postoperative rehabilitation strategy. This section reports only those 40 studies that described their postoperative rehabilitation strategy, focusing on weight-bearing, immobilisation and other therapy administered.

Weight-bearing

To simplify the narrative synthesis, studies were grouped according to when weight-bearing was commenced following surgery (immediate; early: 2-3 weeks and late: 4-12 weeks). Out of 40 studies, nine implemented immediate weight-bearing (Table 2), 12 studies encouraged early weight-bearing (see Table, Supplemental Digital Content 3, http://links.lww.com/JOT/B766), and 19 studies reported late weight-bearing (see Table, Supplemental Digital Content 4, http://links.lww.com/JOT/B767). One study did not specify any time frames, instead allowing non-weight-bearing walking with crutches only when the patient was pain free.[48] This study was included in the late weight-bearing group (see Table, Supplemental Digital Content 4, http://links.lww.com/JOT/B767).

It was common for studies to report an intermediate period between no weight-bearing and full weight-bearing, referred to as 'partial' or 'as tolerated', but these two terms were rarely defined. Exceptions to this were the studies by Braun et al[28,29] where partial weight-bearing was defined as limited to 20 kg, Turhan et al,[24] where this was specified as 'toe-touch weight-bearing', and Park et al,[40] where it was described as 'forefoot-touch partial'.

Of the studies categorised as immediate weight-bearing, some indicated a progressive increase in weight-bearing from surgery, as tolerated by the patient,[23,25,27,30] whereas others had a cut-off point at 6 weeks when patients were expected to progress from partial to full weight-bearing[24,26,28,29,74] (Table 2). The studies categorised as early weight-bearing included an initial period of no weight-bearing, from one to three weeks, but most frequently two weeks, followed often by a period of partial weight-bearing from two to six weeks, before progressing to full weight-bearing (see Table, Supplemental Digital Content 3, http://links.lww.com/JOT/B766).[31-41,61] Progression to full weight-bearing was described inconsistently, with terms like 'gradual' without further clarification,[31,38] or not described at all.[37,41] In studies categorised as late weight-bearing, patients were advised to remain non-weight-bearing for up to at least four weeks, in most cases six weeks (see Table,

Supplemental Digital Content 4, http://links.lww.com/JOT/B767).[42-47,49-55,58] Other studies advised patients to remain non-weight-bearing for up to 10 to 12 weeks.[42,50,54,55,57,60] Several studies reported patients being non-weight-bearing until fracture healing was confirmed with radiographic evidence.[49,51,56,57,60]

Those studies which included separate cohorts with and without syndesmotic injury or repair[42,49,50,55] specified longer periods of time before full weight-bearing in patients with syndesmotic injury, usually 8 to 12 weeks compared to four to six weeks in patients without syndesmosis disruption.

Immobilisation or support devices

Motion restriction devices reported by the reviewed studies included plaster splints or casts, or walker boots for time periods ranging from one to six weeks, depending on the study. In some studies, these devices were later replaced by removable casts, braces or ankle stirrups to aid in weaning [27,32,34,36,37,42,44] . Wang et al[57] and Zhan et al[51] did not use any immobilisation or devices and six studies[24,28,29,50,59,60] did not report whether any devices were used by patients postoperatively.

Additional details on physical therapy sessions

Fourteen out of 40 studies (35%) did not detail their postoperative rehabilitation therapy, other than a mention[27,30,31,33,34,38,40,41,44,49,50,53,54,74]. All of the remaining studies only provided limited details or a brief explanation of the number of sessions and type of exercises, which primarily targeted range of motion,[24,39,42,43,46-48,51,56,59-61] strength,[47] proprioception[46,47] and indicated the number or timing of sessions.[23,25,28,29,45,46,56,57,59,60] Other studies gave more details of their programmes involving timing of exercises[55] and range of motion.[54] Suciu et al[52] described their rehabilitation therapy in the greatest detail outlining an exercise

programme, spanning from in-hospital exercises to outpatient rehabilitation up to 12 weeks post-surgery.

Effectiveness of postoperative rehabilitation strategies

Summaries of the 15 studies that focused on evaluating the effectiveness of rehabilitation strategies are in Table 3 and Table 4. Of those 15 studies, eight studies focused on the timing of weight-bearing (Table 3) and seven tested different therapy protocols (Table 4). Of the 8 studies comparing weight-bearing interventions, two compared immediate versus late weight-bearing,[22,62] four compared early weight-bearing from two weeks, against late weight-bearing, starting at six weeks,[63,65-67] and two others compared 3 weeks (early) against 6 weeks (late).[64,68] A wide range of primary outcomes were used (Table 3, Table 4). Of the eight studies comparing weight-bearing interventions, 3 reported better primary outcomes in the early weight-bearing group compared to the late weight-bearing groups, all of which measured outcomes over the short-term (2 to 12 weeks).[65,66,68] The other studies showed no differences or similar outcomes across groups.[22,62-64,67] Importantly, the 4 studies examining long-term outcomes of 6 or 12 months showed similar outcomes for both groups.[62-64,67]

Of the seven studies that looked at the effectiveness of different rehabilitation programs, exercise programs varied widely and could therefore not be compared (Table 4). None of the studies reported clinically significant differences between groups, except for Sultan et al[69] that showed better Olerud-Molander scores in the Class II compression stocking group compared to the Tubigrip compression stocking group at 6 months.

DISCUSSION

This review aimed to explore the specific characteristics and the reported effectiveness of postoperative rehabilitation strategies in ankle fractures. Our review revealed 55 articles published in the past 10 years, many of poor quality (47%). Forty studies described postoperative rehabilitation strategies without evaluating effectiveness while 15 focused on evaluating effectiveness. The characteristics of postoperative rehabilitation strategies varied widely and were poorly described in a way that could not be replicated. Most studies utilised a late weight-bearing approach although definitions and details around weight-bearing were unclear. This may not necessarily be a methodological oversight, but a reflection on the difficulties of quantifying weight-bearing forces in a clinical setting.

Our findings highlight a lack of detail in postoperative protocols after surgical repair of ankle fractures. The included studies do not provide sufficient information on rehabilitation strategies to replicate these protocols, determine their influence on specific outcomes, or to implement them in clinical practice. Timeframes and/or the magnitude of load around weight-bearing are qualified with terms such as 'partial', 'as tolerated' or 'progressive' which can mean different things to different clinicians and patients. For example, partial and progressive, in the absence of specific instructions, seem to have the same meaning as 'as tolerated'; partial, because the patient cannot tolerate full weight-bearing, and progressive, because as the pain lessens, the patient will naturally increase weight-bearing. Further, a noticeable omission is the lack of studies that quantified the amount of weight patients should be exerting on the operated limb at each phase of the recovery journey. While setting specific weight or pressure limits would allow better comparison in the literature, studies with insole pressure measurements have shown that patients are unable to reproduce defined pressure restrictions, rendering that approach unreliable.[76] Therefore, a pragmatic approach is required, acknowledging that patients will likely weight-bear as far as is comfortable (i.e. as

tolerated), regardless of instructions provided. Further studies could attempt to elucidate the ideal timing of weight-bearing and adherence to weight-bearing protocols, using technology, to improve understanding of the best postoperative rehabilitation strategies. Only two papers were identified that adopted this approach.[28,29] However, in-depth study of the feasibility and acceptability of biofeedback devices is needed if they are to be widely implemented.[77]

Our narrative synthesis revealed that three studies reported better outcomes on their primary outcome in the early weight-bearing group compared to the late weight-bearing group in the short-term (2 to 12 weeks),[65,66,68] but studies looking at long-term outcomes (6 to 12 months) did not report differences across groups.[62-64,67] In contrast, the 2021 systematic review and meta-analysis by Sernandez et al,[13] which included 20 randomized controlled trials looking at weight-bearing in ankle fractures after ORIF, reported no difference in outcomes between early and delayed weight-bearing. Another systematic review including 25 randomized controlled trials and cohort studies reported earlier return to work and daily activities in those performing ankle exercises compared to immobilization.[11] In addition, most studies reported no significant differences in the rate of complications,[11] or surgical site infections, wound healing or union in early compared to delayed weight-bearing groups.[64-66] This suggests that prescribing early weight-bearing does not impact patient safety, and may have advantages including the ability to carry out daily activities sooner. In fact, some studies have suggested there can be problems associated with delayed weight-bearing, including higher likelihood of need for removal of instrumentation due to irritation.[63] Based on these observations, the evidence to support delayed weight-bearing is weak and yet 18 studies in our review used late weight-bearing as postoperative strategy. Despite three systematic reviews published between 2009 and 2015 that concluded that early weight-bearing and mobilisation can accelerate a return daily activities and work, several studies have continued to use delayed weight-bearing

protocols[7,8,11] , which suggests clinicians may be unaware of the evidence and previously published reviews have not improved knowledge about best practice.

This review is the first to focus in detail on how current postoperative rehabilitation strategies are described and their specific characteristics. It is a comprehensive review of studies published in the last 10 years, and thus likely to reflect the current standards of practice. To progress research comparison and clinical practice around postoperative strategies for ankle fractures, we propose that weight-bearing is defined as 'early' if instituted two weeks from the date of surgery and 'late' if instituted six weeks or later. This will assist the classification of trials and provide a clear guidance to clinicians. Despite the variety of rehabilitation protocols, the timing of weight-bearing ('early' or 'late') seems to have an effect in short term function but does not appear to affect long term outcome. Therefore, given the potential psychosocial benefits of returning to usual activities sooner,[78] it would appear warranted to encourage early weight-bearing, if the patient's clinical context does not preclude it. Limitations of this review include low quality of evidence, also reflected in our narrative synthesis, as most studies did not report sufficient details on their postoperative rehabilitation strategies to enable replication by other researchers and provide guidance to clinicians. It is important to note that our findings reflect those of the primary outcomes only, which may limit generalisability.

The variety of definitions of weight-bearing used and the lack of detail of rehabilitation regimes are factors that limit the replication or validation of the studies. This is a serious methodological shortcoming that impact clinical practice. Weight-bearing and the timing of weight-bearing postoperatively seems to be an important factor, with early weight-bearing potentially improving short-term outcomes without appearing to compromise long-term outcomes. As proposed by the authors, future studies should focus on adopting consistent

definitions and terminology around postoperative rehabilitation to ultimately improve patient outcomes.

REFERENCES

1. Bettin C, Nelson R, Rothberg D, Barg A, Lyman M, Saltzman C. Cost comparison of surgically treated ankle fractures managed in an inpatient versus outpatient setting. *J Am Acad Orthop Surg.* 2019;27(3):e127-e134.
2. Wu A-M, Bisignano C, James SL, et al. Global, regional, and national burden of bone fractures in 204 countries and territories, 1990-2019: a systematic analysis from the Global Burden of Disease Study 2019. *Lancet Healthy Longev.* 2021;2(9):e580-e592.
3. Jensen CM, Serritslev R, Abrahamsen C. Patients perspective on treatment and early rehabilitation after an ankle fracture: a longitudinal qualitative study. *Int J Orthop Trauma Nurs.* 2021:100916.
4. Dangor S, Jayaraman-Pillay P, Maddocks S, Chetty V. Pre-operative physiotherapy following unilateral ankle fractures at a tertiary hospital in South Africa: perceptions of patients and nurses. *S Afr J Physiother.* 2021;77(1):1501.
5. Nash WJ, Hester T, Ha J. Current concepts and challenges in managing ankle fractures in the presence of diabetes: a systematic review of the literature. *J Clin Orthop Trauma.* 2021;3(17):44-53.
6. Keene DJ, Williamson E, Bruce J, Willett K, Lamb SE. Early ankle movement versus immobilization in the postoperative management of ankle fracture in adults: a systematic review and meta-analysis. *J Orthop Sports Phys Ther.* 2014;44(9):690-C697.
7. Thomas G, Whalley H, Modi C. Early mobilization of operatively fixed ankle fractures: a systematic review. *Foot Ankle Int.* 2009;30(7):666-674.

8. Black J, Bhavikatti M, Al-Hadithy N, Hakmi A, Kitson J. Early weight-bearing in operatively fixed ankle fractures: a systematic review. *The Foot.* 2013;23(2-3):78-85.
9. Lin C, Moseley A, Refshauge K. Effects of rehabilitation after ankle fracture: a Cochrane systematic review. *Eur J Phys Rehabil Med.* 2009;45(3):431-441.
10. Lin CWC, Donkers NA, Refshauge KM, Beckenkamp PR, Khera K, Moseley AM. Rehabilitation for ankle fractures in adults. *Cochrane database of systematic reviews.* 2012;14:11.
11. Smeeing DP, Houwert RM, Briet JP, et al. Weight-bearing and mobilization in the postoperative care of ankle fractures: a systematic review and meta-analysis of randomized controlled trials and cohort studies. *PLoS One.* 2015;10(2):e0118320.
12. Smith TO, Davies L. When should open reduction and internal fixation ankle fractures begin weight bearing? A systematic review. *Eur J Trauma Emerg Surg.* 2008;34(1):69-76.
13. Sernandez H, Riehl J, Fogel J. Do early weight-bearing and range of motion affect outcomes in operatively treated ankle fractures: a systematic review and meta-analysis. *J Orthop Trauma.* 2021;35(8):408-413.
14. Swart E, Bezhani H, Greisberg J, Vosseller JT. How long should patients be kept non-weight bearing after ankle fracture fixation? A survey of OTA and AOFAS members. *Injury.* 2015;46(6):1127-1130.
15. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clinical Epidemiol.* 2009;62(10):e1-e34.
16. Plinsinga M, Manzaneron S, Johnston V, et al. Characteristics of postoperative rehabilitation strategies in ankel fracture: protocol for a systematic review. PROSPERO 2020 CRD42020191532.

https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020191532. Accessed 10.01.2022.

17. National Heart, Lung, and Blood Institute. Study Quality Assessment Tools. https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools. Accessed 10.01.2022.

18. Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ.* 2014;348:g1687.

19. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics.* 1977;33(1):159-174.

20. Henkelmann R, Palke L, Schneider S, et al. Impact of anti-gravity treadmill rehabilitation therapy on the clinical outcomes after fixation of lower limb fractures: a randomized clinical trial. *Clin Rehabil.* 2021;35(3):356-366.

21. Palke L, Schneider S, Karich B, et al. Anti-gravity treadmill rehabilitation improves gait and muscle atrophy in patients with surgically treated ankle and tibial plateau fractures after one year: a randomised clinical trial. *Clin Rehabil.* 2021;Online ahead of print. doi:10.1177/02692155211037148

22. Cunningham BP, Dugarte AJ, McCreary DL, et al. Immediate weightbearing after operative treatment of bimalleolar and trimalleolar ankle fractures: faster return to work for patients with nonsedentary occupations. *J Foot Ankle Surg.* 2021;60(1):11-16.

23. Pakarinen HJ, Flinkkilä TE, Ohtonen PP, et al. Syndesmotic fixation in supination-external rotation ankle fractures: a prospective randomized study. *Foot Ankle Int.* 2011;32(12):1103-1109.

24. Turhan E, Doral MN, Demirel M, et al. Arthroscopy-assisted reduction versus open reduction in the fixation of medial malleolar fractures. *Eur J Orthop Surg Traumatol.* 2013;23(8):953-959.

25. Kortekangas TH, Pakarinen HJ, Savola O, et al. Syndesmotic fixation in supination-external rotation ankle fractures: a prospective randomized study. *Foot Ankle Int.* 2014;35(10):988-995.

26. Kortekangas T, Savola O, Flinkkilä T, et al. A prospective randomised study comparing TightRope and syndesmotic screw fixation for accuracy and maintenance of syndesmotic reduction assessed with bilateral computed tomography. *Injury.* 2015;46(6):1119-1126.

27. Firoozabadi R, Harnden E, Krieg JC. Immediate weight-bearing after ankle fracture fixation. *Adv Orthop.* 2015;2015:491976.

28. Braun BJ, Bushuven E, Hell R, et al. A novel tool for continuous fracture aftercare–clinical feasibility and first results of a new telemetric gait analysis insole. *Injury.* 2016;47(2):490-494.

29. Braun BJ, Veith NT, Rollmann M, et al. Weight-bearing recommendations after operative fracture treatment—fact or fiction? Gait results with and feasibility of a dynamic, continuous pedobarography insole. *Int Orthop.* 2017;41(8):1507-1512.

30. King CM, Doyle MD, Castellucci-Garza FM, Nguyentat A, Collman DR, Schuberth JM. Early protected weightbearing after open reduction internal fixation of ankle fractures with trans-syndesmotic screws. *J Foot Ankle Surg.* 2020;59(4):726-728.

31. Rangdal S, Singh D, Joshi N, Soni A, Sament R. Functional outcome of ankle fracture patients treated with biodegradable implants. *Foot Ankle Surg.* 2012;18(3):153-156.

32. Sanders DW, Tieszer C, Corbett B. Operative versus nonoperative treatment of unstable lateral malleolar fractures: a randomized multicenter trial. *J Orthop Trauma*. 2012;26(3):129-134.

33. Tsukada S, Otsuji M, Shiozaki A, et al. Locking versus non-locking neutralization plates for treatment of lateral malleolar fractures: a randomized controlled trial. *Int Orthop*. 2013;37(12):2451-2456.

34. Mayich DJ, Tieszer C, Lawendy A, McCormick W, Sanders D. Role of patient information handouts following operative treatment of ankle fractures: a prospective randomized study. *Foot Ankle Int.* 2013;34(1):2-7.

35. Asloum Y, Bedin B, Roger T, Charissoux J-L, Arnaud J-P, Mabit C. Internal fixation of the fibula in ankle fractures. A prospective, randomized and comparative study: plating versus nailing. *Orthop Traumatol-Sur*. 2014;100(4):S255-S259.

36. Gaiarsa GP, Reis PRd, Mattar R, Silva JdS, Fernandez TD. Comparative study between osteosynthesis in conventional and bioabsorbable implants in ankle fractures. *Acta ortopedica brasileira*. 2015;23:263-267.

37. Mittal R, Harris IA, Adie S, Naylor JM. Surgery for type B ankle fracture treatment: a combined randomised and observational study (CROSSBAT). *BMJ Open.* 2017;7(3):e013298.

38. Chun D-I, Sharma AR, Ulagpan A, Jagga S, Lee S-S, Cho J. A novel remedy for isolated weber b ankle fractures: surgical treatment using a specialized anatomical locking plate. *Biomed Res* 2017;28(19):8417-8422.

39. Buckley R, Kwek E, Duffy P, et al. Single-screw fixation compared with double screw fixation for treatment of medial malleolar fractures: a prospective randomized trial. *J Orthop Trauma*. 2018;32(11):548-553.

40. Park YH, Ahn JH, Choi GW, Kim HJ. Comparison of clamp reduction and manual reduction of syndesmosis in rotational ankle fractures: a prospective randomized trial. *J Foot Ankle Surg*. 2018;57(1):19-22.

41. Yeung C-Y, Hung S-H, Hsu K-H, Chiu F-Y. Early full weight-bearing in patients with isolated displaced lateral malleolar fracture after rigid internal fixation with locking plates. *J Chin Med Assoc*. 2021;84(4):438-440.

42. Jordan C, Davidovitch RI, Walsh M, Tejwani N, Rosenberg A, Egol KA. Spinal anesthesia mediates improved early function and pain relief following surgical repair of ankle fractures. *JBJS*. 2010;92(2):368-374.

43. Miller AN, Carroll EA, Parker RJ, Helfet DL, Lorich DG. Posterior malleolar stabilization of syndesmotic injuries is equivalent to screw fixation. *Clin Orthop Relat Res*. 2010;468(4):1129-1135.

44. Noh JH, Roh YH, Yang BG, Kim SW, Lee JS, Oh MK. Outcomes of operative treatment of unstable ankle fractures: a comparison of metallic and biodegradable implants. *J Bone Jt Surg*. 2012;94(22):e166.

45. Hong CC, Roy SP, Nashi N, Tan KJ. Functional outcome and limitation of sporting activities after bimalleolar and trimalleolar ankle fractures. *Foot Ankle Int.* 2013;34(6):805-810.

46. Hong CC, Nashi N, Roy SP, Tan KJ. Impact of trimalleolar ankle fractures: how do patients fare post-operatively? *Foot Ankle Surg*. 2014;20(1):48-51.

47. Kilonzo N, Mwangi H, Lelei L, Nyabera S, Ayumba B. Treatment and outcome of ankle fractures at the Moi Teaching and Referral Hospital. *Ann Afr Surg*. 2014;11:1.

48. D'Almeida VR, Thomas A, Devasia T, Mathew N, Kamath A, Adiga R. Functional outcome following operative treatment of ankle fractures. *J Evol Med Dent Sci*. 2015;4(63):10937-10956.

49. Kim MB, Lee YH, Kim JH, Lee JE, Baek GH. Lateral transmalleolar approach and miniscrews fixation for displaced posterolateral fragments of posterior malleolus fractures in adults: a consecutive study. *J Orthop Trauma*. 2015;29(2):105-109.

50. Litrenta J, Saper D, Tornetta III P, et al. Does syndesmotic injury have a negative effect on functional outcome? A multicenter prospective evaluation. *J Orthop Trauma*. 2015;29(9):410-413.

51. Zhan Y, Yan X, Xia R, Cheng T, Luo C. Anterior-inferior tibiofibular ligament anatomical repair and augmentation versus trans-syndesmosis screw fixation for the syndesmotic instability in external-rotation type ankle fracture with posterior malleolus involvement: a prospective and comparative study. *Injury*. 2016;47(7):1574-1580.

52. Suciu O, Onofrei RR, Totorean AD, Suciu SC, Amaricai EC. Gait analysis and functional outcomes after twelve-week rehabilitation in patients with surgically treated ankle fractures. *Gait Posture*. 2016;49:184-189.

53. Karam E, Shivji F, Bhattacharya A, et al. A cross-sectional study of the impact of physiotherapy and self directed exercise on the functional outcome of internally fixed isolated unimalleolar Weber B ankle fractures. *Injury*. 2017;48(2):531-535.

54. Wang X, Zhang C, Yin Jw, et al. Treatment of medial malleolus or pure deltoid ligament injury in patients with supination-external rotation type IV ankle fractures. *Orthop Surg*. 2017;9(1):42-48.

55. Sun X, Li T, Sun Z, et al. Does routinely repairing deltoid ligament injuries in type B ankle joint fractures influence long term outcomes? *Injury*. 2018;49(12):2312-2317.

56. Xian H, Miao J, Zhou Q, Lian K, Zhai W, Liu Q. Novel elastic syndesmosis hook plate fixation versus routine screw fixation for syndesmosis injury. *J Foot Ankle Surg*. 2018;57(1):65-68.

57. Wang L, Zhang Y, Song Z, Chang H, Tian Y, Zhang F. A novel method of using elastic bionic fixation device for distal tibiofibular syndesmosis injury. *Int Orthop.* 2018;42(9):2219-2229.

58. Ho SW, Yam M, Chan M, Kwek EB. Return to car driving is safe 6 weeks after operative treatment of right ankle fractures. *Arch Orthop Trauma Surg.* 2018;138(12):1691-1697.

59. Elwahab MRA, Eid AS, Kotb A, El-ghammaz S. Is posterolateral plating better for fixation of Weber B distal fibular fractures than lateral plating: a randomized controlled clinical trial and a review of the literature. *Curr Orthop Pract.* 2020;31(1):58-66.

60. Yeshwanth s, Vishnu S, Damodharan. Evaluation of functional outcome following ORIF of bimalleolar fractures of the ankle-A prospective study of 30 patients. *Int J Res Pharm Sci.* 2020;11(4):6051-6055.

61. Tang J, Hu J-F, Guo W-c, Yu L, Zhao S-h. Research and application of absorbable screw in orthopedics: a clinical review comparing PDLLA screw with metal screw in patients with simple medial malleolus fracture. *Chin J Traumatol.* 2013;16(1):27-30.

62. Ağır İ, Tunçer N, Küçükdurmaz F, Gümüstaş S, Akgül ED, Akpinar F. Functional comparison of immediate and late weight bearing after ankle bimalleolar fracture surgery. *Open Orthop J.* 2015;9:188-190.

63. Dehghan N, McKee MD, Jenkinson RJ, et al. Early weightbearing and range of motion versus non-weightbearing and immobilization after open reduction and internal fixation of unstable ankle fractures: a randomized controlled trial. *J Orthop Trauma.* 2016;30(7):345-352.

64. Passias BJ, Korpi FP, Chu AK, et al. Safety of early weight bearing following fixation of bimalleolar ankle fractures. *Cureus.* 2020;12(4):e7557.

65. Schubert J, Lambers KT, Kimber C, et al. Effect on overall health status with weightbearing at 2 weeks vs 6 weeks after open reduction and internal fixation of ankle fractures. *Foot Ankle Int.* 2020;41(6):658-665.

66. Smeeing DPJ, Houwert RM, Briet JP, et al. Weight-bearing or non-weight-bearing after surgical treatment of ankle fractures: a multicenter randomized controlled trial. *Eur J Trauma Emerg Surg.* 2020;46(1):121-130.

67. Park JY, Kim BS, Kim YM, Cho JH, Choi YR, Kim HN. Early weightbearing versus nonweightbearing after operative treatment of an ankle fracture: a multicenter, noninferiority, randomized controlled trial. *Am J Sports Med.* 2021;49(10):2689-2696.

68. Zyskowski M, Wurm M, Greve F, et al. Is early full weight bearing safe following locking plate ORIF of distal fibula fractures? *BMC Musculoskelet Disord.* 2021;22(1):1-10.

69. Sultan M, Zhing T, Morris J, Kurdy N, McCollum C. Compression stockings in the management of fractures of the ankle: a randomised controlled trial. *Bone Jt J.* 2014;96(8):1062-1069.

70. Jansen H, Jordan M, Frey S, Hölscher-Doht S, Meffert R, Heintel T. Active controlled motion in early rehabilitation improves outcome after ankle fractures: a randomized controlled trial. *Clin Rehabil.* 2018;32(3):312-318.

71. Büker N, Şavkın R, Ök N. Comparison of supervised exercise and home exercise after ankle fracture. *J Foot Ankle Surg.* 2019;58(5):822-827.

72. Ferguson CM, Harmer L, Seymour RB, et al. Does formal vs home-based physical therapy predict outcomes after ankle fracture or ankle fracture-dislocation? *OTA International.* 2019;2(2):e039.

73. Molund M, Hellesnes J, Berdal G, Andreassen BS, Andreassen GS. Compared to conventional physiotherapy, does the use of an ankle trainer device after Weber B

ankle fracture operation improve outcome and shorten hospital stay? A randomized controlled trial. *Clin Rehabil.* 2020;34(8):1040-1047.

74. Ræder BW, Andersen MR, Madsen JE, Jacobsen SB, Frihagen F, Figved W. Prognostic value of the Haraguchi classification in posterior malleolar fractures in A0 44-C type ankle fractures. *Injury.* 2021;52(10):3150-3155.

75. Moseley AM, Beckenkamp PR, Haas M, Herbert RD, Lin C-WC, Team E. Rehabilitation after immobilization for ankle fracture: the EXACT randomized clinical trial. *JAMA.* 2015;314(13):1376-1385.

76. Vasarhelyi A, Baumert T, Fritsch C, Hopfenmüller W, Gradl G, Mittlmeier T. Partial weight bearing after surgery for fractures of the lower extremity--is it achievable? *Gait Posture.* 2006;23(1):99-105. doi: 10.1016/j.gaitpost.2004.12.005.

77. Jagtenberg EM, Kalmet PHS, De Krom MAP, Blokhuis TJ, Seelen HAM, Poeze M. Feasibility and validity of ambulant biofeedback devices to improve weight-bearing compliance in trauma patients with lower extremit fractures: a narrative review. *J Rehabil Med*. 2020;52:jrm0000X. doi:10.2340/16501977-2621.

78. Lorente A, Gandía A, Mariscal G, Palacios P, Lorente R. Quality of life and complications in elderly patients after pronation rotation type III ankle fractures treated with a cast and early weight-bearing. *BMC Musculoskelet Disord*. 2021;22(1):878.

FIGURE LEGEND

Figure 1: PRISMA Flowchart showing review process.

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Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Published randomized controlled trials and cohort studies that describe or evaluate one or more postoperative rehabilitation strategies for ankle fractures. This includes retrospective analyses from prospectively collected data. • Studies investigating surgical repair of ankle fractures via Open Reduction with Internal Fixation (ORIF). Surgical techniques include but are not limited to band wires, intramedullary nails, staples and pins, plates, and screws. • Studies that included human adult populations (age ≥18 years). • Studies that describe isolated ankle fractures needing surgery include Weber A/ Lauge Hansen supination-adduction, Weber B/ Lauge Hansen supination-exorotation, Weber/ Lauge Hansen pronation-exorotation, and AO-OTA 44A-C with limited posterior involvement. • Studies published in English. • Studies published since 1 January 2010.	• Studies that conduct surgical techniques other than ankle ORIF. For example, studies investigating techniques such as arthrodesis (i.e. joint fusion) or arthroscopy for management of ankle fractures or arthritis of the ankle. • Studies describing surgical strategies but that do not describe or assess postoperative *rehabilitation*. • Populations that require deviations from the 'usual' postoperative care, for example frail/elderly and diabetic patients. • Retrospective studies/review, case (series) studies, reviews, protocol papers. • Studies investigating economic outcomes of surgical techniques. • Studies that investigated calcaneus fractures, pilon fractures, talus fractures, osteoporotic fractures, ankle fractures associated with ipsilateral (mid)foot fractures/ contralateral foot/ankle fractures, stress fractures.

Table 1: Summary of studies with immediate weight-bearing protocols, not assessing effectiveness

Study and year	Syndesmotic injury	Weight-bearing	Devices	Rehabilitation Therapy
Pakarinen et al, 2011[23]	Yes	As tolerated from surgery	Below-knee cast up to 4 weeks	Physiotherapist provided rehabilitation instructions at 4 and 12 week visits
Turhan et al, 2013[24]	No	Toe-touch weight-bearing up to 6 weeks, then full weight-bearing	Not reported	ROM exercises: active from 1 day and passive from 2 weeks
Kortekangas et al, 2014[25]	Yes	As tolerated from surgery	Below-knee cast up to 4 weeks	Physiotherapist provided rehabilitation instructions at 4 and 12 week visits
Kortekangas et al, 2015[25]	Yes	Partial weight bearing up to 6 weeks. Weight bearing as tolerated after 6 weeks.	Below-knee cast up to 6 weeks	Physiotherapist provided rehabilitation instructions at 6 weeks
Firoozabadi et al, 2015[27]	No	As tolerated from surgery	Controlled Ankle Motion Walker Boot – wean progressively up to 6 weeks. Removable ankle stirrup to aid in weaning	Not reported
Braun et al, 2016[28]	No	20 kg limit, up to 6 weeks, supervised increase to full weight-bearing from 6 weeks	Not reported	Supervised physical therapy after 6 weeks. Minimum of 5 sessions. Patients instructed to control their weight bearing at least weekly on a bathroom scale during the first 6 weeks.
Braun et al, 2017[29]	No	20 kg limit, up to 6 weeks, supervised increase to full weight-bearing from 6 weeks	Not reported	5 sessions as inpatient, then twice weekly for 6 weeks
King et al, 2020[30]	Yes	As tolerated within 15 days	Short leg walking cast	Not reported

Study and year	Syndesmotic injury	Weight-bearing	Devices	Rehabilitation Therapy
Ræder et al, 2021[74]	Yes	Partial up to 6 weeks, full weight-bearing encouraged from 6 weeks	Postoperative plaster cast until discharge for only a few patients	Not reported

ROM = Range of motion

Table 3: Studies comparing the effectiveness of different weight-bearing timing

Study and year	Weight-bearing groups	Primary outcome	Results*	Preferred treatment
Ağır et al, 2015[62]	Immediate Late (6 weeks)	AOFAS at 12 months	*Immediate*: Excellent (n=3), good (n=14), moderate (n=7), poor (n=2). *Late*: Excellent (n=3), good (n=11), moderate (n=11), poor (n=2).	Similar outcomes for both immediate and late weight-bearing groups.
Dehghan et al, 2016[63]	Early (2 weeks) Late (6 weeks)	Patients returned to work at 12 months (%)	*Early*: 98% *Late*: 98% p = 0.95	No significant difference in return to work rates.
Passias et al, 2020[64]	Early (3 weeks) Late (6 weeks)	Fracture union rates at 6 months (%)	*Early*: 38/38 (100%) *Late*: 55/57 96.5% p-value 0.51	No significant difference in fracture union rates.
Schubert et al, 2020 [65]	Early (2 weeks) Late (6 weeks)	EQ-5D Visual Analogue Scale (VAS) at 2 weeks	*Early*: 70.7 (14.4) *Late*: 63.3 (16.1) p = 0.1	Early weight-bearing - higher scores were observed in the early weight-bearing group. However, the EQ-5D VAS is not a validated tool. This study did not use the EQ-5D questionnaire correctly and therefore the scores reported against that outcome cannot be used.
Smeeing et al, 2020[66]	Immediate (24 hours) Early (protected, from 10 days) Late (6 weeks)	Olerud-Molander score at 6 weeks	*Immediate*: 61.2 (19.0) *Early*: 51.8 (20.4) *Late*: 45.8 (22.4) p = 0.011	Immediate weight-bearing led to improved outcomes.
Cunningham et al, 2021[22]	Immediate (24 hours) Traditional (6 weeks)	Time to return to work	*Immediate:* 5.5 weeks *Traditional:* 8.3 weeks p = 0.08	No significant differences in time to return to work.

Study and year	Weight-bearing groups	Primary outcome	Results*	Preferred treatment
Park et al, 2021[67]	Early (2 weeks) Late (6 weeks)	Olerud-Molander ankle score at 12 months	*Early*: 89.9 (9.2) *Late*: 85.5 (12.7) p = 0.02	Early weight-bearing – better functional scores but not clinically significant .
Zyskowski et al, 2021[68]	Locking plate system and early full weight-bearing (3 weeks) Semitubular plate and late full weight-bearing (6 weeks)	Olerud-Molander ankle score at 6 and 12 weeks	6 weeks *Early:* 56.05 (12) *Late:* 45.22 (18) p = 0.02 12 weeks *Early:* 69.47 (14) *Late: 59.79 (16)* p = 0.04	Early weight-bearing - Polyaxial locking plate with early weight-bearing leads to better functional outcomes.

**Reported as Mean (Standard Deviation), unless otherwise described. AOFAS = American Orthopaedic Foot & Ankle Society Score*

Table 4: Studies comparing the effectiveness of different rehabilitation programs

Study and year	Rehabilitation Groups	Primary outcome	Results*	Preferred treatment
Sultan et al, 2014[69]	Class II Compression stocking Tubigrip Compression stocking	Olerud-Molander ankle score at 6 months	*Compression*: 98 (95% Confidence Interval: 96 – 99) *Tubigrip*: 64 (95% Confidence Interval: 62 – 73) p <0.001	Class II Compression stocking: outcome were better in the Class II compression stocking group and considered statistically significant.
Jansen et al, 2018[70]	Physiotherapy Active controlled motion	ROM (degrees) in ankle and subtalar joints at 12 weeks	*Physiotherapy*: Ankle joint: 53.6 (4.7) Subtalar joint: 19.1 (7.5) *Active controlled motion:* Ankle joint: 58.2 (12.4) Subtalar joint: 23.4 (6.8) Ankle joint: p = 0.08 Subtalar joint: p <0.01	Active controlled motion: outcomes were better for ROM and other measures in that group and clinically meaningful. Not all were considered statistically significant.
Büker et al, 2019[71]	Supervised exercise program Home exercise program	AOFAS at final follow-up (27.86 ≥ 9.88 months)	*Supervised*: 76.63 (17.46) *Home*: 83.75 (15.15) p = 0.036	Home exercise: Patients in that group had better AOFAS scores that were statistically significant but not clinically significant. There were no statistically significant differences on other measures.
Ferguson et al, 2019[72]	Clinic-based physical therapy Home-based physical therapy	Foot and ankle ability measure (FAAM) at 6 months	*Clinic*: 69.7 *Home*: 70.9 p = 0.868 (SDs not reported)	Home-based group: patients had higher scores across all measures but results were not clinically significant. There were no statistically significant differences between groups.
Molund et al, 2020[73]	Conventional non-elastic band New spring-loaded ankle trainer	Olerud-Molander ankle score at 3 weeks	*Conventional:* 35.3 (14.2) *New:* 40.9 (10.8) p = 0.021	New spring-loaded ankle trainer: patients treated with new ankle trainer had statistically significant, but not clinically significant, functional recovery scores at 3 weeks. No significant differences were found at longer timepoints.

Study and year	Rehabilitation Groups	Primary outcome	Results*	Preferred treatment
Henkelmann et al, 2021[20] *	Antigravity treatment rehabilitation Standard rehabilitation	Foot and Ankle Outcome Score at 6 weeks	*Antigravity:* 54.2 (16.1) *Standard:* 56.0 (16.6) Difference 6 weeks vs baseline: p = 0.89	No statistically or clinically significant differences.
Palke et al, 2021[21]	Antigravity treatment rehabilitation Standard rehabilitation	Foot and Ankle Outcome Score at 12 months	*Antigravity:* 80.8 (18.4) *Standard:* 78.4 (21.1) p = 0.98	No statistically or clinically significant differences.

**Reported as Mean (Standard Deviation), unless otherwise described, AOFAS = American Orthopaedic Foot & Ankle Society score. ROM = Range of Motion. Note that Henkelmann and Palke used data from the same trial.*