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ARTICLE

Comparative outcomes between surgical treatment and orthosis splint for mallet finger: a systematic review and meta-analysis

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ABSTRACT
Mallet finger is a commonly encountered condition in daily practice. However, there is currently no consensus on whether surgical intervention or conservative treatment with orthosis splint is superior. In this systematic review and meta-analysis, we compare the treatment outcomes between surgery and orthosis for bony and tendinous mallet finger. We searched PubMed, Embase, and the Cochrane Library according to the PRISMA guidelines from inception to January 15, 2021. The primary outcome was distal interphalangeal (DIP) joint extension lag angle, and secondary outcomes were DIP joint flexion and range of motion (ROM) angle. A total of 297 studies were initially identified, of which 13 (ten retrospective non-randomized controlled studies (non-RCTs) and three RCTs) were included in the final analysis. The results of this systematic review and meta-analysis showed that there was no high level of evidence supporting the superiority of surgery over orthosis in the treatment of mallet finger. Based on the available evidence, surgical intervention and conservative treatment with splint may offer similar clinical outcomes in both bony and tendinous mallet finger.

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KEYWORDS
Mallet finger; surgery; orthosis splint; outcome; systematic review; meta-analysis

Introduction

Mallet finger is a common hand injury involving the extensor tendon with either tendon rupture or bony avulsion at the base of the distal phalanx leading to limited active extension of the distal interphalangeal joint (DIP) [1–3]. The cause of mallet finger is usually forceful flexion or hyperextension to the tip of the finger [4–7]. Disruption of the terminal extensor tendon results in extension lag of the DIP joint and drop finger. If left untreated, a mallet finger can be complicated by the development of stiffness, osteoarthritis or swan-neck deformity [8–10].

There is currently no consensus regarding the optimal treatment of mallet finger. A number of surgical techniques and conservative treatments have been proposed over the past several decades, however the optimal method is still under debate. The treatment options for tendinous and bony mallet which affects less than one-third of the DIP joint are mainly conservative [11–14]. However, surgical intervention is necessary for an open injury, when splinting cannot correct acute deformities, or in cases of poor compliance during splint immobilization [15]. Traditionally, some authors recommend surgical treatment if the mallet injury involves palmar subluxation or more than one-third of the articular surface of the distal phalanx [16–19].

Surgical treatment may include Kirschner wire (K-wire) extension block pinning, pull-in suture, pull-out wire, tenodermodesis, open reduction and fixation, hook plate, and tension band wire [20–27], while conservative management may include different types of splint such as Abouna orthosis, Stack orthosis, a volar or dorsal aluminium splint, and custom-fabricated thermoplastic splints [11,28–35]. Although many studies have described the treatment outcomes of different surgical and conservative treatment methods, comparative studies are limited. In addition, the treatment outcomes of surgical versus nonsurgical treatment in previous studies have been inconsistent. Therefore, the purpose of this study was to summarize the outcomes between surgical treatment and orthosis for bony and tendinous mallet finger with further meta-analysis.

Material and methods

This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [36]. This study was registered at the PROSPERO website (ID number CRD42021235788).

Search strategy and inclusion criteria

We searched PubMed, Embase, and the Cochrane Library from inception to January 15, 2021 for studies comparing surgical treatment and splint for bony or tendinous mallet finger. The search strategy comprised the following keywords: (mallet finger or mallet fracture or mallet injury or baseball finger or drop finger) AND (surgery or surgical treatment or K-wire extension block pinning or pull-out wire fixation or internal fixation or percutaneous pinning) AND (splint or orthosis or splintage or conservative treatment or nonoperative). Medical Subject Headings (MeSH) terms were used in combination with Boolean operators (AND, OR, NOT).

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Studies were considered eligible if they were retrospective, cohort studies, non-randomized controlled trials and randomized controlled trials (RCTs) which compared the treatment outcomes between surgical intervention and splint for mallet finger. The exclusion criteria were patients with mallet thumb or chronic mallet finger, and those younger than 18 years. The bibliographies of eligible RCTs and related review articles were manually reviewed for relevant references for any missing studies. Literature not written in English was translated for further evaluation.

We included RCTs and comparative non-randomized controlled studies (non-RCTs), and excluded case reports, review articles, meta-analyses, editorials, commentaries and letters to the editor. All articles that fulfilled the inclusion criteria were retrieved for full-text evaluation.

Data extraction and quality assessment

Two reviewers (CHL and CP) examined all of the retrieved articles and extracted data. Disagreements between the two reviewers were discussed with a third reviewer (YTL) until a consensus was reached. Extracted variables included general study characteristics (author, year of publication, study design, and number of patients), clinical characteristics (classification of mallet finger), treatment characteristics (surgical technique, type of orthosis, and outcome evaluation method), primary and secondary outcomes (DIP joint extension lag, total active range of motion of the DIP joint, active DIP joint flexion, and success rate), and complications. In cases of incomplete information in the included studies, we contacted the authors *via* e-mail.

Risk of bias assessment

The quality of the enrolled studies was evaluated by two reviewers independently using the Revised Cochrane Risk of Bias (RoB 2.0) tool for RCTs and the Risk of Bias in Non-randomized Studies of Interventions (ROBIN-I) tool for comparative retrospective studies [37,38].

Data synthesis and analysis

The primary outcome was DIP joint extension lag between surgery and splint. The secondary outcomes were active DIP joint flexion, active DIP joint range of motion, and complications. We used the quantity I^2, with a range from 0% to 100%, to test for variation across studies that was due to heterogeneity rather than to chance, and to quantify the effect of heterogeneity. An I^2 value of more than 50% was considered to indicate notable heterogeneity.

The results were expressed in terms of odds ratio (OR) and 95% confidence interval (95% CI) for dichotomous outcomes, and mean difference (MD) and 95% CI for continuous outcomes. Due to the retrospective nature of most studies, a random effects model was used to pool individual MDs and ORs. Statistical analyses were performed using Review Manager version 5.4 software (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). Statistical significance was defined as p-values < 0.05.

Results

A total of 297 potentially relevant studies were initially identified through the search. After the titles and abstracts of these articles had been reviewed for relevance, 77 articles remained, and the full text of these articles were evaluated. Ultimately, 13 articles fulfilled the inclusion criteria and were included (Figure 1). Of these 13 articles, ten were retrospective non-RCTs and the remaining three were RCTs. The characteristics of the eligible studies, main treatment outcomes, and complications are summarized in Table 1. A total of 233 patients who were treated with surgical treatment and 295 who were treated with orthosis splint were included in the systematic review. In one (Thillemann et al.) of the RCTs, one patient in each group left the study during the follow-up period, leaving 14 patients in each of the two groups (6.6% drop out rate).

The pooled results of the RCTs and non-RCTs were analyzed first, and we divided the treatment outcomes into subgroups based on the study design.

Analysis of treatment outcomes

Only three of the non-RCTs had available data for the meta-analysis. These three non-RCTs and the three RCTs included a total of 236 patients, including 114 in the surgery group and 122 in the splint group.

A total of 98 patients were included in the three RCTs, including 47 in the surgery group and 51 in the splint group [39–41]. The surgical techniques were trans-DIP K wire, suture anchor + Trans-DIP K-wire, and K wire extension block pinning, and the types of splint were Pryor and Howard splints, aluminum splints, and palmar padded aluminum splints.

Of the 10 non-RCTs studies, three had available and sufficient data to be included in the meta-analysis [42–51]. A total of 138 patients were included in these three studies, including 67 in the surgery group and 71 in the splint group. The surgical techniques were K wire extension block pinning, oblique K-wire fixation, and absorbable bone anchor, and the type of splints were plastic stack orthosis or volar aluminum foam splints, custom thermoplastic splints, and metal splints.

Post-operative DIP joint extension lag angle

Pooled analysis of the RCTs and non-RCTs

In the pooled analysis (3 RCTs and 3 non-RCTs), there was no significant difference between the surgery and splint groups in post-operative DIP joint extension lag angle (MD = −3.00, 95% CI = −6.37, 0.38; $p = 0.08$). Significant heterogeneity was found among the six studies ($I^2 = 60\%$; $p = 0.03$) (Figure 2).

Subgroup analysis of the RCTs

No significant heterogeneity was found among the three studies ($I^2 = 34\%$; $p = 0.22$), and there was no significant difference between the surgery and splint groups (MD = −0.58, 95% CI = −4.35, 3.19; $p = 0.76$)

Subgroup analysis of the non-RCTs

Significant heterogeneity was found among the three studies ($I^2 = 64\%$; $p = 0.06$). There was a significantly better treatment outcome with regards to post-operative DIP joint extension lag angle in the surgery group (MD = −5.14, 95% CI = −10.17, −0.11; $p = 0.05$)

Post-operative DIP joint flexion angle

Pooled analysis of the RCTs and non-RCTs

In the pooled analysis (3 RCTs and 3 non-RCTs), there was no significant difference between the surgery and splint groups in

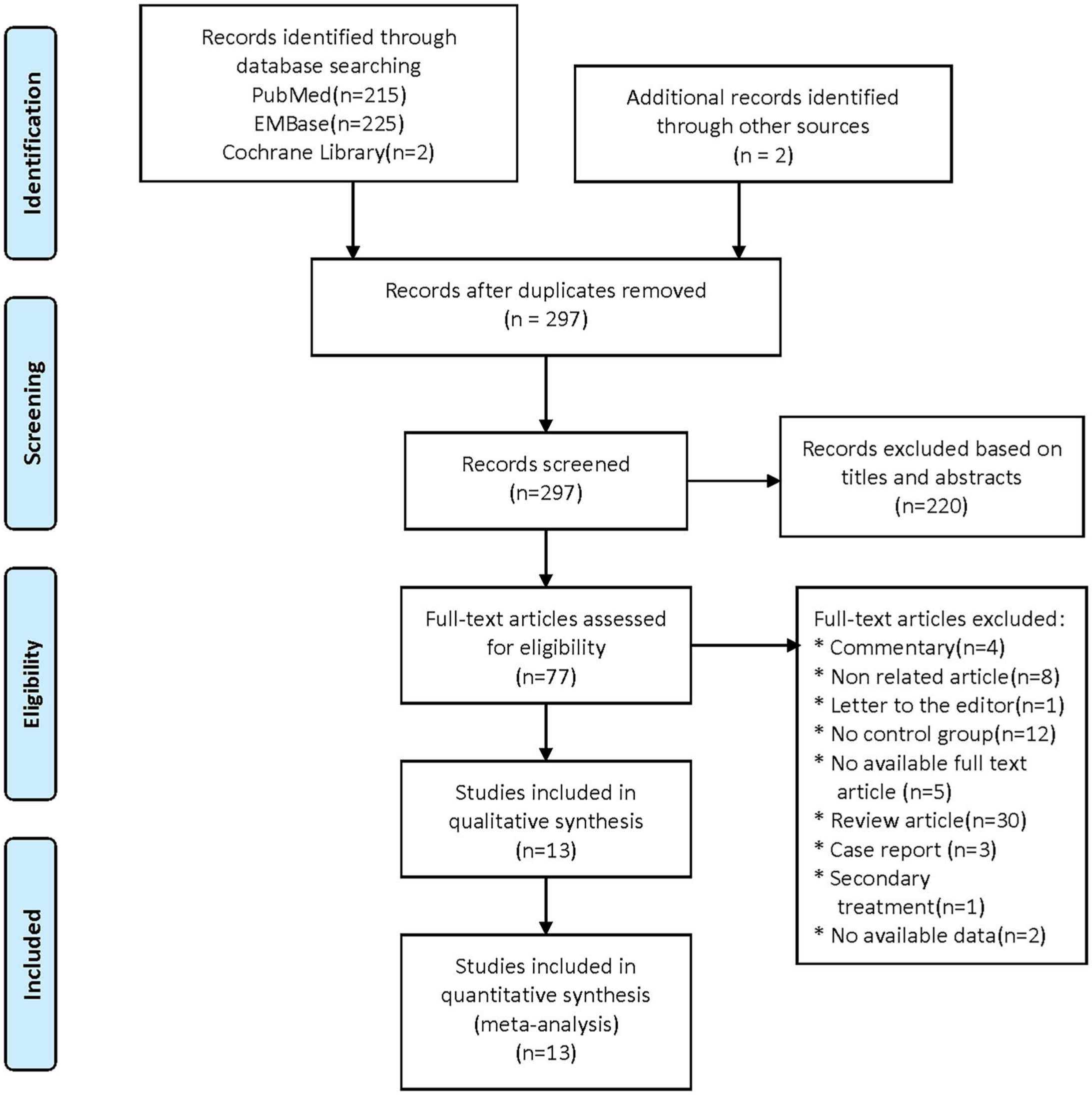

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the search and identification of the included studies.

post-operative DIP joint flexion angle (MD = 1.40, 95% CI = −1.22, 4.02; $p = 0.29$). No significant heterogeneity was found among the six studies ($I^2 = 26\%$; $p = 0.24$) (Figure 3).

Subgroup analysis of the RCTs

Significant heterogeneity was found among the three studies ($I^2 = 74\%$; $p = 0.02$). A random effects model was used, and the results revealed no significant difference between the surgery and splint groups (MD = −4.23, 95% CI = −10.98, 2.52; $p = 0.22$).

Subgroup analysis of the non-RCTs

No significant heterogeneity was found among the three studies ($I^2 = 0\%$; $p = 0.52$). There was a significantly better outcome with regards to DIP joint flexion angle in the surgery group (MD = 3.01, 95% CI = 0.08, 5.93; $p = 0.04$).

Post-operative DIP joint total active range of motion

Pooled analysis of the RCTs and non-RCTs

Five studies (3 RCTs and 2 non-RCTs) were pooled into the meta-analysis. There was no significant difference between the surgery and splint groups in post-operative DIP joint total active range of motion (MD = 0.91, 95% CI = −7.40, 9.22; $p = 0.83$). There was significant heterogeneity among the five studies ($I^2 = 77\%$; $p = 0.001$) (Figure 4).

Subgroup analysis of the RCTs

Significant heterogeneity was found among the three studies ($I^2 = 74\%$; $p = 0.05$), and there was no significant difference between the surgery and splint groups (MD = −4.00, 95% CI = −13.78, 5.79; $p = 0.42$).

Subgroup analysis of the non-RCTs

Only two non-RCTs had available data for the meta-analysis. A total of 99 patients were included in these two studies, including 46 in the surgery group and 53 in the splint group. Significant heterogeneity was found between the two studies ($I^2 = 87\%$; $p = 0.006$), and there was no significant difference in post-operative DIP joint total active range of motion between the surgery and splint groups (MD = 8.27, 95% CI = −8.27, 24.80; $p = 0.33$).

Complications

The 13 studies included 255 patients who received a surgical intervention and 334 who received splint treatment (including those were lost to follow-up) and reported complications. The

Table 1. Characteristics of the included studies.

Characteristics of included studies						Results of treatment			
Study	Design	Number of cases (Conservative /Surgery)	Type of mallet finger	Conservative treatment	Surgical treatment	DIP Joint Extension Deficit (Conservative vs. Surgery)	Active DIP Joint Flexion (Conservative vs. Surgery)	Active DIP joint range of motion (Conservative vs. Surgery)	**Outcome evaluation**
Auchincloss [39]	RCT	22/19	Tendinous, bony and open cut tendon	Pryor and Howard splint	Trans-DIP K-wire	10 vs. 6.05	83.9 vs. 83.4	73.4 vs. 77.89	Stark criteria, ROM Hand function
Batıbay et al. [40]	RCT	15/14	W-S type IA, IB, IIA and IIB	Aluminum splint	Suture anchor + Trans-DIP K-wire	6.1 vs. 8.1	58.3 vs. 54.5	51.53 vs. 45.76	Crawford's criteria, Abouna criteria, VAS, DIP joint Flexion, lag, Return to work
Thillemann et al. [41]	RCT	14/14	W-S type IB and IC	Palmar padded aluminium splint	K-wire extension block pinning	12 vs. 10	65 vs. 50	53 vs. 39	Extension lag, ROM, flexion, Finger-to-palm distance, QDASH, Pain scores
Wehbé and Schneider [42]	NRCT	15/6	W-S types mallet fractures	Aluminum-foam splint or Stack splint	Internal fixation with K-wire and pull-out wire suture and trans-DIP K-wire fixation	Splint: <10 degree:11 10–30 degree:4 Surgery: <10 degree:4 10–30 degree:2	Not report	Splint: <30 degree:1; 30–60 degree:6; >60 degree: 8 Surgery: <30 degree:1 ; 30–60 degree:2; >60 degree:3	Extension lag, ROM, pain, functional impairment, dorsal bump
Niechajev [43]	NRCT	5/12	Mallet fractures	Aluminum splint	Open reduction, pull-out wire suture and trans-DIP K-wire	10–15 degrees: 2/6; 15–20 degrees: 1/2; 20 degrees: 1/2	Not report	Not report	Extension defect, flexion defect, ROM outer appearance, pain
Clement and Wray [44]	NRCT	23/24	Tendinous and bony	Stack splint	Reinsertion of extensor tendon	15 vs. 10	55 vs. 40	40 vs. 40	Extension lag, flexion and ROM of DIP and PIP joint
Stern and Kastrup [45]	NRCT	44/23[a]	Tendinous and bony	Dorsal DIP aluminum foam, Stack, Volar DIP aluminum foam, Sugar Tong aluminium foam, Thermoplastic	Trans-articular fixation with 1 pin, trans-articular fixation with 1 pin + pin(s) for fragment fixation, trans-articular fixation with 1 pin + pull-out wire, tendon grafts	8 vs. 7	64 vs. 49	Not report	Extension lag, Flexion, long and short-term complications
Lubahn [46]	NRCT	19/11	Not reported	Dorsal alumaform splint or link-type splint	Trans-DIP K-wire + ORIF with K-wire	20–30 vs. 0–20	50–60 vs. 40–65	35 vs. 55	Extension lag, flexion, ROM
Ma et al. [47]	NRCT	24/16	Closed mallet fracture	Metal splint external fixation	Absorbable bone anchor system	4.80 vs. 2.81	36.73 vs. 38.75	32.69 vs. 33	Extension lag, flexion, ROM, TAM system, Recurrence rate
Renfree et al. [48]	NRCT	44/17	Tendinous and Bony	Custom thermoplastic splint	K-wire percutaneous pinning	10 vs. 5	53 vs. 46	Not report	Extension lag, flexion, satisfaction
Yoon et al. [49]	NRCT	23/26	Bony mallet finger without high degree subluxation	Volar aluminium splint	K-wire extension block pinning	8 vs. 5	78 vs. 73	Not report	Extension lag, flexion, VAS, Crawford's criteria, Dorsal prominence
Nagura et al. [50]	NRCT	29/30	Tendinous mallet finger	Custom thermoplastic splint	Oblique K-wire fixation	13.8 vs. 2.1	63.4 vs. 69	49.7 vs. 66.9	Extension lag, flexion, Miller's criteria
Gumussuyu et al. [51]	NRCT	18/21	W-S type IB and IC	Plastic stack orthosis or volar aluminum foam splint	K-wire extension block pinning	9.7 vs. 6.0	55.2 vs. 62.8	Not report	Extension lag, flexion, Crawford's criteria, VAS, Aesthetic results, cost

[a]Exclude 6 fingers which were treated with surgery and conservative treatment.
W-S: Wehbe-Schneider classification: Type IA: no volar subluxation, <1/3 fragment size of articular surface. Type IB: no volar subluxation, between 1/3 and 2/3 fragment size of articular surface. Type IIA: volar subluxation, <1/3 fragment size of articular surface. Type IIB: volar subluxation, between 1/3 and 2/3 fragment size of articular surface. RCT: Randomized controlled trial; NRCT: Non randomized controlled trial; VAS: Visual analogue scale; ROM: Range of motion; DIP: Distal interphalangeal; K-wire: Kirschner wire; ORIF: Open reduction and internal fixation.

surgical complications included pin tract infection, osteomyelitis, nail deformity and dystrophy, cold intolerance, and dorsal prominence, and the splint complications included local irritation, pressure ulcer, skin maceration or ulceration, dorsal bump, and secondary subluxation. No significant heterogeneity was found among the 13 studies ($I^2 = 0\%$; $p = 0.60$), and there was no significant difference in complications between the surgery and splint groups (OR = 1.20, 95% CI = 0.76, 1.90; $p = 0.43$) (Figure 5, Table 2).

Risk of bias assessment

In the risk of bias assessment of the RCTs, the greatest concerns were related to allocation concealment and in the blinding of outcome assessment. For risk of bias assessment of the non-RCTs, nine studies had a serious risk of bias and only one had a moderate risk of bias (Figures 6 and 7).

Discussion

Over the past decades, numerous surgical and conservative treatments for mallet finger have been described. Nevertheless, the optimal management strategy for mallet finger is still under debate, and no consensus has been reached about whether surgery or splint is superior. Few RCTs have compared conservative treatment with surgical intervention, and most comparative articles have been non-randomized and retrospective. In addition, patient selection (bony, tendinous or both), bony mallet finger classification, outcome evaluation methods, data recording, surgical techniques, and conservative methods have varied among these studies.

In the present systematic review and meta-analysis, we enrolled studies which reported the treatment outcomes between patients who received surgery and splint for both bony and tendinous mallet finger. In the pooled results of RCTs and non-RCTs,

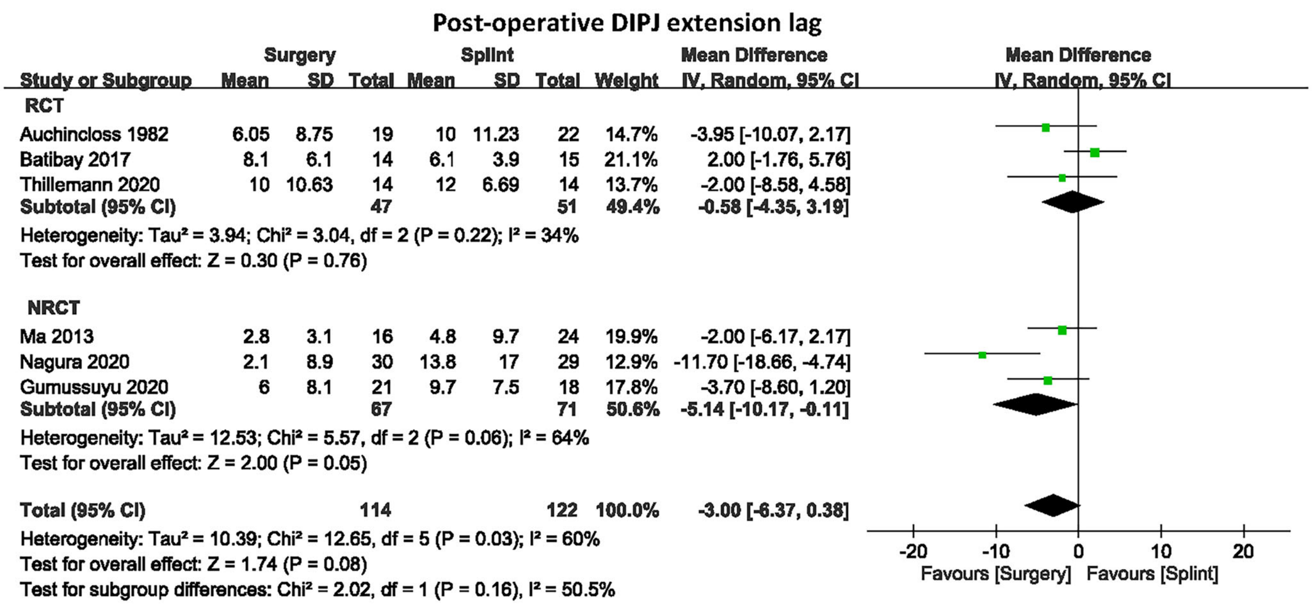

Figure 2. Meta-analysis of distal interphalangeal (DIP) joint extension lag in randomized control trials (RCTs) and non-randomized control trials (non-RCTs).

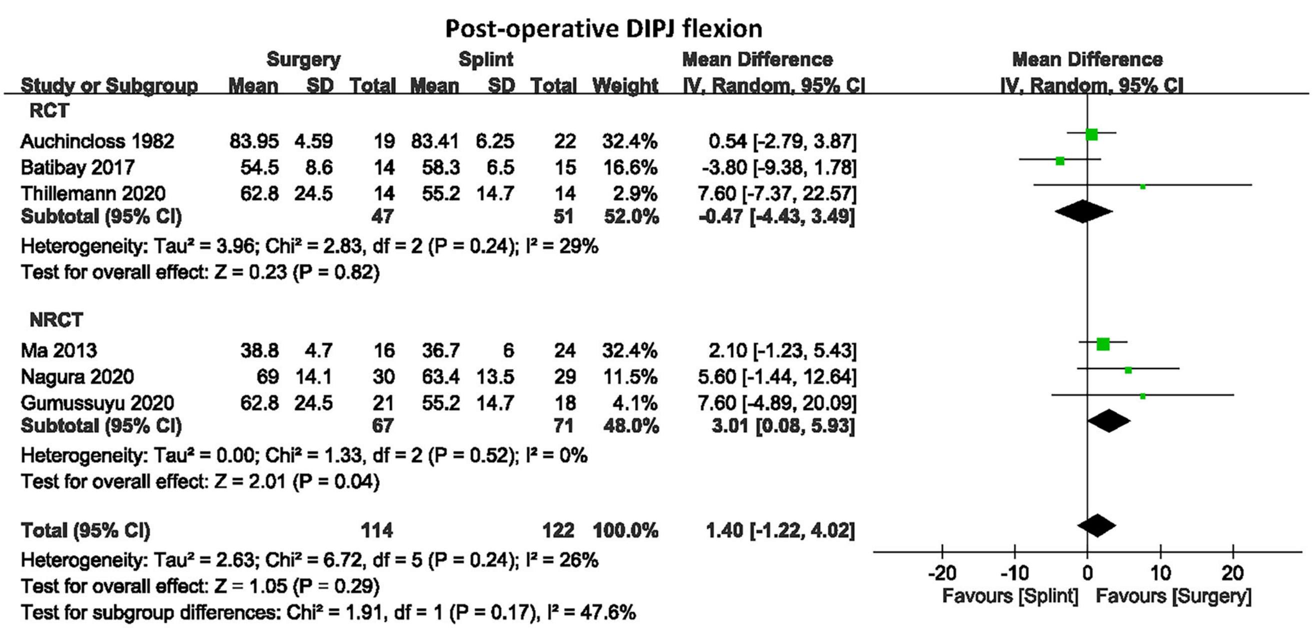

Figure 3. Meta-analysis of DIP joint flexion in the RCTs and non-RCTs.

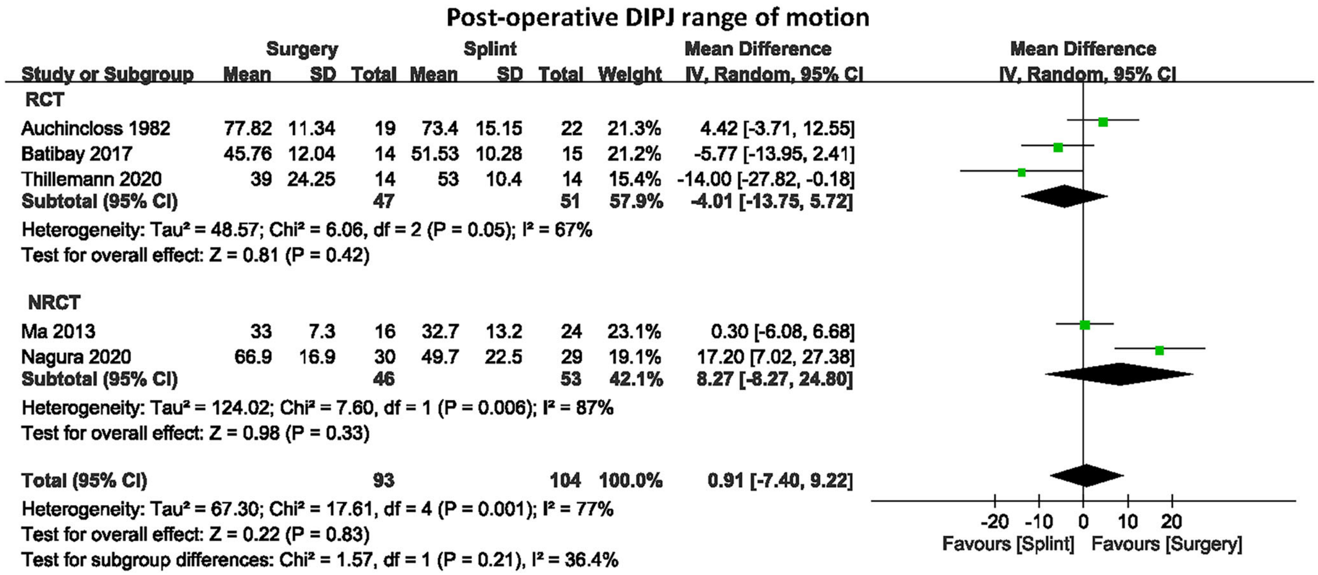

Figure 4. Meta-analysis of DIP joint range of motion in the RCTs and non-RCTs.

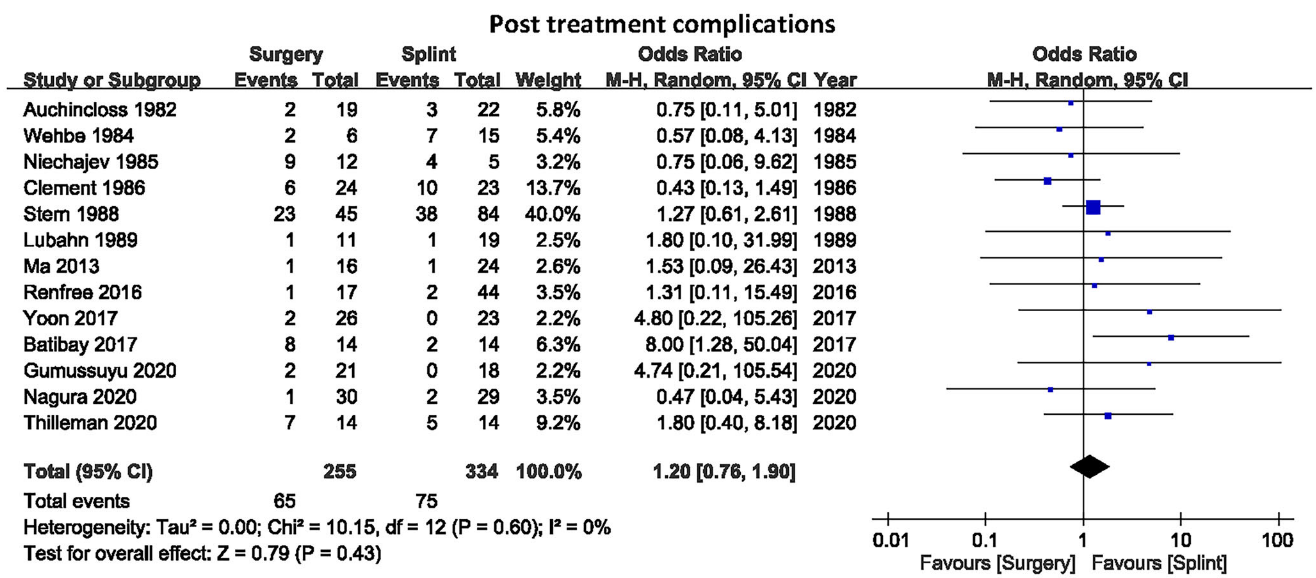

Figure 5. Meta-analysis of complications in the RCTs and non-RCTs.

no significant outcome differences in DIP joint extension lag, flexion and total range of motion were found between surgical intervention and splint treatment. We further performed subgroup analysis according to study design. In the RCT group, no significant differences in the primary and secondary treatment outcomes between surgery and splint were found. On the other hand, surgical intervention seemed to provide superior results regarding DIP joint extension lag and flexion angle in the retrospective non-RCT group. Regarding complications, all of the studies were pooled, and the result showed no significant difference between surgical intervention and conservative treatment.

There were differences in the results according to different study design and also pooled results. There are several possible reasons for these differences. First, heterogeneity of the populations and subtypes of mallet finger may have affected the results. The patients with bony mallet finger had different subtypes of Wehbe-Schneider classification, and patient group selection with regards to bony or tendinous mallet finger varied between studies. Second, each enrolled studies included a small number of patients. Third, a limited number of articles directly compared two different treatment modalities (surgery versus splint). Fourth, various and limited treatment results were described in the studies, leading to unified outcome measurements.

Similar treatment outcomes were found among the three RCTs, even though patient selection, surgical method and type of splint differed. Auchincloss [39] did not describe the type of injury (both open and closed injury were included), and suggested surgical interventions for patients with delayed treatment from injury. However, few patients with a mallet finger injury treated within two weeks by either method have significant persistent disability. Batıbay et al. [40] only included patients with bony mallet finger (Wehbe-Schneider type IA, IB, IIA, and IIB) and found no difference between conservative versus surgical treatment, however they reported that conservative treatment was more cost-effective. Thillemann et al. [41] also included patients with bony mallet finger (Wehbe-Schneider type IB and IC), and they

Table 2. Complications reported in the included studies.

	Conservative treatment	Surgery
Auchincloss [39]	Local severe irritation:3	Infection:2
Batibay et al. [40]	Secondary subluxation:1 Nail disorder:2	Secondary subluxation:2 Osteomyelitis:1 Infection:3 Nail disorder:4
Thillemann et al. [41]	Nail deformities:2 Dorsal bump at PIP joint:7 Swan-neck deformity:3	Nail deformities:4 Dorsal bump at PIP joint:5 Swan- neck deformity:3
Wehbé and Schneider [42]	Severe dorsal bump:1 Minor dorsal bump:12 Joint narrowing:8	Minor dorsal bump:5 Joint narrowing:3
Niechajev [43]	Drooping:1 Bulging of the operated area:2, Hypersensitivity to cold:1	Significantly drooping:1, Bulging of the operated area:3 Hypersensitivity to cold:5
Clement and Wray [44]	Cold intolerance:10	Cold intolerance:6
Stern and Kastrup [45]	Dorsal ulceration or marceration:19/8 Tape allergy:2 Nail deformity:5 Pain:5	Infection:9, Nail deformity:8 Joint incongruity:8 Pin or pull-out wire failure:6 Other deformity:5 Increased lag:2 Tendon overadvanced:1
Lubahn [46]	Partial thickness dorsal skin slough:1	Pin tract infection:1
Ma et al. [47]	None	Local swelling and skin redness:1
Renfree et al. [48]	Swan-neck deformity:1, Pressure ulcer:1	Cellulitis:1 Pin migration and swan-neck deformity:1
Yoon et al. [49]	None	Nail deformities:2
Nagura et al. [50]	Skin maceration:2	Pin site infection:1
Gumussuyu et al. [51]	none	Pin tract infection:1 Nail dystrophy:1

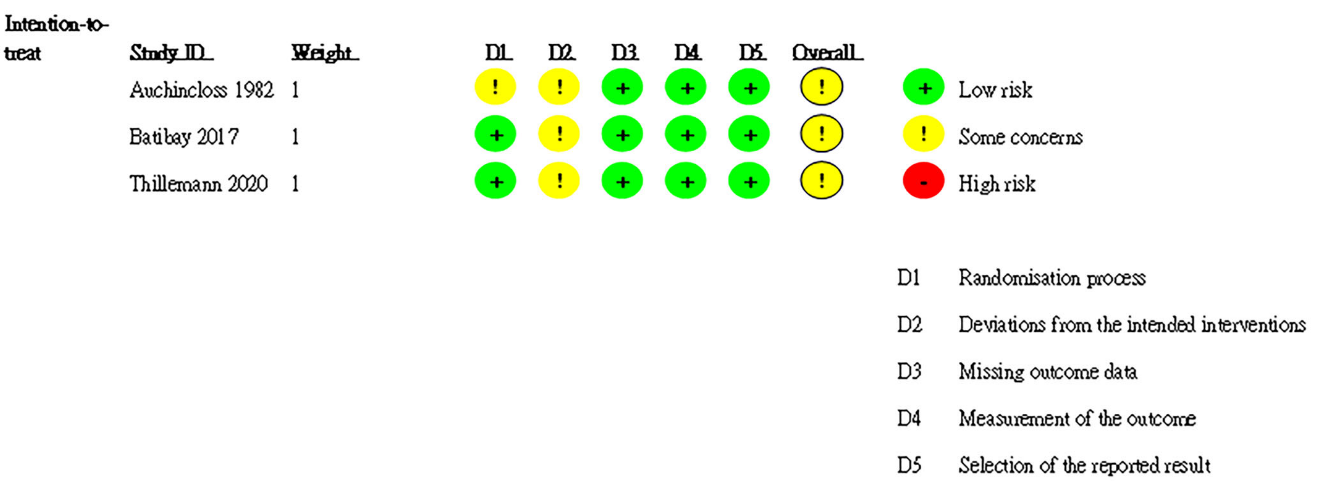

Figure 6. Risk of bias in the randomized control trials (RCTs).

concluded that splint for mallet finger injury is safe and efficient to restore joint function, but not sufficient to prevent secondary subluxation of the joint.

In the three retrospective non-RCT studies included in the meta-analysis, Ma et al. [47] suggested that an absorbable bone anchor system was significantly better than metal splint external fixation, but that the cost limits its application. Nagura et al. [50] reviewed only acute closed tendinous mallet finger, and found that surgical treatment with K-wire fixation provided better outcomes with regards to extension lag of the DIP joint and a lower treatment failure rate. Gumussuyu et al. [51] retrospectively reviewed patients with bony mallet finger (Wehbe-Schneider IB and IC) and reported similar clinical and radiological results of conservative and surgical treatment. Nevertheless, the direct medical, indirect and cumulative costs were significant higher in the surgical group (surgery: EUR 915.4±442.2; conservative treatment: EUR 300.3±279.4). Considering the cumulative cost, extension splints provide a more cost-effective and appropriate treatment option.

In the systematic review by Lin et al. [52], the average DIP joint extension lag was 5.7 versus 7.6 degrees comparing surgical and nonsurgical treatment, respectively. Our meta-analysis of retrospective studies is consistent with theirs, in that surgical treatment may offer a better outcome with regards to DIP joint extension lag, but that the difference with nonsurgical treatment is likely clinically insignificant. A Cochrane review and meta-analysis by Handoll and Vaghela included four RCTs concluded that there was insufficient evidence to determine when surgical intervention is indicated. Different from our study, their review included studies which compared different methods of

Figure 7. Risk Of Bias Of Non Randomized Controlled Trials								
Study	ROBINS-I Domains							
	D1	D2	D3	D4	D5	D6	D7	Overall
Wehbe et al, 1984	Orange	Green	Yellow	Green	Orange	Orange	Green	Orange
Niechajev, 1985	Orange	Green	Yellow	Green	Orange	Orange	Green	Orange
Clement et al, 1986	Orange	Orange	Yellow	Green	Green	Orange	Green	Orange
Stern et al, 1988	Orange	Green	Orange	Green	Orange	Orange	Green	Orange
Lubahn, 1989	Orange	Orange	Yellow	Green	Green	Orange	Green	Orange
Ma et al, 2013	Orange	Green	Yellow	Green	Green	Orange	Green	Orange
Renfree et al, 2016	Orange	Orange	Yellow	Orange	Green	Green	Green	Orange
Yoon et al, 2017	Yellow	Orange	Yellow	Green	Green	Green	Green	Orange
Nagura et al, 2020	Yellow	Green	Yellow	Green	Green	Yellow	Green	Yellow
Gumussuyu et al, 2020	Yellow	Green	Orange	Green	Green	Green	Green	Orange

D1:Bias due to confounding; D2:Bias in selection of participants; D3:Bias in classification of interventions; D4:Bias due to deviations from intended interventions; D5:Bias due to missing data; D6:Bias in measurement of outcomes; D7:Bias in selection of reported results.

Green: Low risk; Yellow: Moderate risk; Orange: Serious risk

Figure 7. Risk of Bias of Non-randomized Studies of Interventions (ROBIN-I).

conservative treatment (perforated custom-made splint versus Stack splint; padded aluminium-alloy malleable finger splint versus Stack splint; Abouna splint versus Stack splint) [53].

Most authors recommended using the fracture fragment size (more than one-third of articular surface involvement) and subluxation of the distal phalanx as indications for surgery. In addition, an open fracture and chronic mallet finger injury have also been reported to be indications for surgical intervention [54]. Nevertheless, some studies have suggested conservative treatment for almost all types of mallet finger, even for bony mallet fingers with large fracture fragments and subluxation. Wehbe and Schneider concluded that splinting is safe and reliable for mallet finger, while surgical treatment is difficult and does not offer any advantage over conservative treatment [42]. Patient compliance is also a main issue when receiving splint treatment for about six to eight weeks. Some patients remove the orthosis or flex the DIP joint when changing the splint during the treatment period, which can cause loss of reduction and reduce the success rate. In addition, the patients' occupation and nature of work should also be taken into consideration. Some authors have suggested that surgical intervention is appropriate for manual workers such as healthcare professionals and musicians who require fine hand skills and would have difficulty working while wearing the orthosis [55].

Even though the results of subgroup analysis based on the study design with regards to DIP joint extension lag and flexion angle were not identical, we still believe that both surgery and splinting provide similar and favorable outcomes for mallet finger injury. This concept is also supported by the pooled results of meta-analysis and subgroup analysis of the RCTs rather than simply from the non-RCTs.

In a previous study about the functional range of motion of finger joints, Bain et al. reported that a DIP joint with a range of motion of 10 to 60 degrees could cope with 90% of the activities of daily living [56]. Similarly, Hume et al. reported that the functional range of motion for DIP joints ranged from 20 to 61 degrees [57]. The goals of treatment for mallet finger are to restore active DIP joint extension lag and maintain flexion mobility. Among the included studies in the present study, about 70% (9/13) of the conservative treatment groups and 46% (6/13) of the surgical intervention groups had a favorable functional range of motion of the DIP joint.

With regards to the complications rate, no significant difference was found in our meta-analysis between surgical and conservative treatment. The complications of conservative treatment are frequent and most often benign and transient. Skin lesions, including ulceration, local irritation, maceration, superficial infection and dorsal bump, are especially common. The complications of surgical intervention are usually serious and long-term, including nail dystrophy or deformity, pin tract infection, osteomyelitis and skin necrosis [58]. Stern and Kastrup reported complication rates of surgery and splint of 53% and 45%, respectively. They also found that only one finger (4%) with splint had a long-term complication, a minor nail deformity. However, 76% of the surgical complications were long-term [45].

There are several limitations to this study. First, the heterogeneity of the patients was high (bony and tendinous mallet finger) in the included studies. Second, various outcomes were assessed and different data recording methods were used, which made it difficult to perform the meta-analysis with all of the studies. Third, the wide variety of surgical techniques and different types of splints among the pooled studies.

In spite of differences in patient selection, surgical techniques and conservative methods with orthosis splint, we still summarized all of the currently available data in this systematic review. Our findings add to the knowledge as few articles have addressed this issue. In general, both surgical and conservative treatment for mallet finger provide relatively reliable outcomes.

Conclusion

In this systematic review and meta-analysis, we found that there was no high level of evidence supporting the superiority of surgery over orthosis in the treatment of mallet finger. In addition, we found that surgical intervention and conservative treatment with orthosis splint may offer similar clinical outcomes in both bony and tendinous mallet finger.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

[1] Snow JW. Surgical repair of mallet finger. Plast Reconstr Surg. 1968;41(1):89–90.
[2] Stack G. Mallet finger. Lancet. 1968;2(7581):1303.
[3] Stark HH, Boyes JH, Wilson JN. Mallet finger. J Bone Joint Surg Am. 1962;44-a:1061–1068.
[4] Giddins G. Tendinous and bony mallet finger: mechanisms of injury. J Hand Surg Eur Vol. 2021;46(6):682–684.

[5] Lange RH, Engber WD. Hyperextension mallet finger. Orthopedics. 1983;6(11):1426–1431.
[6] McMinn DJ. Mallet finger and fractures. Injury. 1981;12(6): 477–479.
[7] Peterson JJ, Bancroft LW. Injuries of the fingers and thumb in the athlete. Clin Sports Med. 2006;25(3):527–542. vii-viii.
[8] Alla SR, Deal ND, Dempsey IJ. Current concepts: mallet finger. Hand (N Y). 2014;9(2):138–144.
[9] Lamaris GA, Matthew MK. The diagnosis and management of mallet finger injuries. Hand (N Y). 2017;12(3):223–228.
[10] Lin JD, Strauch RJ. Closed soft tissue extensor mechanism injuries (mallet, boutonniere, and sagittal band). J Hand Surg Am. 2014;39(5):1005–1011.
[11] Kalainov DM, Hoepfner PE, Hartigan BJ, et al. Nonsurgical treatment of closed mallet finger fractures. J Hand Surg Am. 2005;30(3):580–586.
[12] Richards SD, Kumar G, Booth S, et al. A model for the conservative management of mallet finger. Journal of Hand Surgery (Edinburgh, Scotland. 2004;29(1):61–63.
[13] Tolkien Z, Potter S, Burr N, et al. Conservative management of mallet injuries: a national survey of current practice in the uk. J Plast Reconstr Aesthet Surg. 2017;70(7):901–907.
[14] Valdes K, Naughton N, Algar L. Conservative treatment of mallet finger: a systematic review. J Hand Ther. 2015;28(3): 237–245; quiz 246.
[15] Suzuki T, Iwamoto T, Sato K. Surgical treatment for chronic tendon mallet injury. J Hand Surg Am. 2018;43(8):780.e1–e5.
[16] Bloom JMP, Khouri JS, Hammert WC. Current concepts in the evaluation and treatment of mallet finger injury. Plast Reconstr Surg. 2013;132(4):560e–566e.
[17] Cheung JP, Fung B, Ip WY. Review on mallet finger treatment. Hand Surg. 2012;17(3):439–447.
[18] Salazar Botero S, Hidalgo Diaz JJ, Benaïda A, et al. Review of acute traumatic closed mallet finger injuries in adults. Arch Plast Surg. 2016;43(2):134–144.
[19] Smit JM, Beets MR, Zeebregts CJ, et al. Treatment options for mallet finger: a review. Plastic Reconstructive Surg. 2010;126:1624–1629.
[20] Ishiguro T, Itoh Y, Yabe Y, et al. Extension block with kirschner wire for fracture dislocation of the distal interphalangeal joint. Tech Hand up Extrem Surg. 1997;1(2):95–102.
[21] Kim DH, Kang HJ, Choi JW. The "fish hook" technique for bony mallet finger. Orthopedics. 2016;39(5):295–298.
[22] Lee SK, Kim HJ, Lee KW, et al. Modified pull-out wire suture technique for the treatment of chronic bony mallet finger. Ann Plast Surg. 2010;65(5):466–470.
[23] Lee YH, Kim JY, Chung MS, et al. Two extension block kirschner wire technique for mallet finger fractures. J Bone Joint Surg Br. 2009;91(11):1478–1481.
[24] Lu J, Jiang J, Xu L, et al. Modification of the pull-in suture technique for mallet finger. Ann Plast Surg. 2013;70(1):30–33.
[25] Tang J, Wu K, Wang J, et al. Open reduction and compression with double kirschner wires for the treatment of old bony mallet finger. J Orthop Surg Res. 2019;14(1):459.
[26] Tung KY, Tsai MF, Chang SH, et al. Modified tenodesis method for treatment of mallet fractures. Ann Plast Surg. 2012;69(6):622–626.
[27] Ulusoy MG, Karalezli N, Koçer U, et al. Pull-in suture technique for the treatment of mallet finger. Plast Reconstr Surg. 2006;118(3):696–702.
[28] Abouna JM, Brown H. The treatment of mallet finger. The results in a series of 148 consecutive cases and a review of the literature. Br J Surg. 1968;55(9):653–667.
[29] Cavanaugh PK, Watkins C, Jones C, et al. Effectiveness of quickcast versus custom-fabricated thermoplastic orthosis immobilization for the treatment of mallet fingers: a randomized clinical trial. Hand (New York, N,Y.). 2022;17(6): 1090–1097.
[30] Devan D. A novel way of treating mallet finger injuries. J Hand Ther. 2014;27(4):325–328; quiz 329.
[31] Kinninmonth AW, Holburn F. A comparative controlled trial of a new perforated splint and a traditional splint in the treatment of mallet finger. Journal of Hand Surgery (Edinburgh, Scotland. 1986;11(2):261–262.
[32] Pike J, Mulpuri K, Metzger M, et al. Blinded, prospective, randomized clinical trial comparing volar, dorsal, and custom thermoplastic splinting in treatment of acute mallet finger. J Hand Surg Am. 2010;35(4):580–588.
[33] Stack HG. A modified splint for mallet finger. J Hand Surg Br. 1986;11(2):263.
[34] Vernet P, Igeta Y, Facca S, et al. Treatment of tendinous mallet fingers using a stack splint versus a dorsal glued splint. Eur J Orthop Surg Traumatol. 2019;29(3):591–596.
[35] Witherow EJ, Peiris CL. Custom-made finger orthoses have fewer skin complications than prefabricated finger orthoses in the management of mallet injury: a systematic review and meta-analysis. Arch Phys Med Rehabil. 2015;96(10): 1913–1923.e1.
[36] Moher D, Liberati A, Tetzlaff J, et al. PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the prisma statement. BMJ. 2009;339:b2535.
[37] Sterne JAC, Savović J, Page MJ, et al. Rob 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019; 366:l4898.
[38] Guyatt GH, Oxman AD, Vist GE, et al. GRADE Working Group. Grade: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008; 336(7650):924–926.
[39] Auchincloss JM. Mallet-finger injuries: a prospective, controlled trial of internal and external splintage. Hand. 1982; 14(2):168–173.
[40] Batıbay SG, Akgül T, Bayram S, et al. Conservative management equally effective to new suture anchor technique for acute mallet finger deformity: a prospective randomized clinical trial. J Hand Ther. 2018;31(4):429–436.
[41] Thillemann JK, Thillemann TM, Kristensen PK, et al. Splinting versus extension-block pinning of bony mallet finger: a randomized clinical trial. J Hand Surg Eur Vol. 2020;45(6):574–581.
[42] Wehbé MA, Schneider LH. Mallet fractures. J Bone Joint Surg Am. 1984;66(5):658–669.
[43] Niechajev IA. Conservative and operative treatment of mallet finger. Plast Reconstr Surg. 1985;76(4):580–585.
[44] Clement R, Wray RC. Jr. Operative and nonoperative treatment of mallet finger. Ann Plast Surg. 1986;16(2):136–141.
[45] Stern PJ, Kastrup JJ. Complications and prognosis of treatment of mallet finger. J Hand Surg Am. 1988;13(3):329–334.
[46] Lubahn JD. Mallet finger fractures: a comparison of open and closed technique. J Hand Surg Am. 1989;14(2 Pt 2):394–396.
[47] Ma WZ, Liang JF, Li WC. Metal splint external fixation versus absorbable bone anchor system to treat closed mallet finger in early stage. Chinese Journal of Tissue Engineering Research. 2013;17:1618–1624.

[48] Renfree KJ, Odgers RA, Ivy CC. Of extension orthosis versus percutaneous pinning of the distal interphalangeal joint for closed mallet injuries. Ann Plast Surg. 2016;76(5):499–503.

[49] Yoon JO, Baek H, Kim JK. The outcomes of extension block pinning and nonsurgical management for mallet fracture. J Hand Surg Am. 2017;42(5):387.e1–e7.

[50] Nagura S, Suzuki T, Iwamoto T, et al. A comparison of splint versus pinning the distal interphalangeal joint for acute closed tendinous mallet injuries. J Hand Surg Asian Pac Vol. 2020;25(2):172–176.

[51] Gumussuyu G, Asoglu MM, Guler O, et al. Extension pin block technique versus extension orthosis for acute bony mallet finger; a retrospective comparison. Orthop Traumatol Surg Res. 2021;107(5):102764.

[52] Lin JS, Samora JB. Surgical and nonsurgical management of mallet finger: a systematic review. J Hand Surg Am. 2018; 43(2):146–163.e2.

[53] Handoll HH, Vaghela MV. Interventions for treating mallet finger injuries. Cochrane Database Syst Rev. 2004;(3):Art. No.:CD00457.

[54] Makhlouf VM, Deek NA. Surgical treatment of chronic mallet finger. Ann Plast Surg. 2011;66(6):670–672.

[55] Freshwater MF. Current concepts in the evaluation and treatment of mallet finger injury. Plast Reconstr Surg. 2014; 133(6):891e–892e.

[56] Bain GI, Polites N, Higgs BG, et al. The functional range of motion of the finger joints. J Hand Surg Eur Vol. 2015; 40(4):406–411.

[57] Hume MC, Gellman H, McKellop H, et al. Functional range of motion of the joints of the hand. J Hand Surg Am. 1990; 15(2):240–243.

[58] King HJ, Shin SJ, Kang ES. Complications of operative treatment for mallet fractures of the distal phalanx. J Hand Surg Br. 2001;26(1):28–31.