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Conservative Treatment of Ulnar Nerve Compression at the Elbow: A Systematic Review and Meta-Analysis

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Abstract

Background The clinical results of conservative treatment options for ulnar compression at the elbow have not been clearly determined. The aim of this review was to evaluate available conservative treatment options and their effectiveness for ulnar nerve compression at the elbow.

Methods In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations, a systematic review and meta-analysis of studies was performed. Literature search was performed using Ovid MEDLINE, Embase, and Cochrane Central Register of Controlled Trials (CENTRAL).

Results Of the 1,079 retrieved studies, 20 were eligible for analysis and included 687 cases of ulnar neuropathy at the elbow. Improvement of symptoms was reported in 54% of the cases receiving a steroid/lidocaine injection (95% confidence interval [CI], 41–67) and in 89% of the cases using a splint device (95% CI, 69–99).

Conclusions Conservative management seems to be effective. Both lidocaine/steroid injections and splint devices gave a statistically significant improvement of symptoms and are suitable options for patients who refuse an operative procedure or need a bridge to their surgery. Splinting is preferred over injections, as it shows a higher rate of improvement.

Keywords
- ulnar nerve compression syndromes
- nerve compression syndromes
- conservative treatment

Introduction

Ulnar nerve compression at the elbow is the second most prevalent entrapment neuropathy of the upper limb. The ulnar nerve travels down the medial side of the elbow, through the cubital tunnel, which is the most common location for entrapment of the ulnar nerve.[1] Repeated flexion of the elbow, muscle malformation, or direct compression can be the source of ulnar nerve compression at the elbow.[2] If remained untreated, the ulnar nerve compression at the

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elbow can lead to chronic loss of sensibility and muscle weakness.[3]

Most patients with ulnar nerve compression at the elbow undergo an operative procedure. However, conservative treatments, including splint devices, corticosteroid injections, physical therapy, and nerve gliding movements, have been described.[1] In cases where the risk of operation is high due to patient comorbidities or when patients have to wait a long time before undergoing a procedure, conservative treatment may be a good treatment option or bridge to surgery. The purpose of this article is to evaluate available conservative treatment options for ulnar nerve compression at the elbow and to review their outcomes.

Methods

This review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations.[4]

Search Methods for the Identification of Studies

The search strategy was conducted in collaboration with an independent librarian in the databases MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials (CENTRAL). The final search was performed in May 2020. In ►**Table 1**, the detailed search methods are displayed. The columns visualize databases that have been used (MEDLINE, Embase, CENTRAL) and the rows are searches with number of hits, stated as results, and the combination of searches. There was no restriction in publication years. Two authors reviewed titles and abstracts of the identified studies, and after selection of relevant studies, the full-text articles were analyzed. Disagreements were resolved by a third reviewer. Cross-referencing took place to identify any additional studies missed in the search.

Selection Criteria

All randomized controlled trials, prospective or retrospective cohort study, case–control studies, or case series were eligible for inclusion. Studies were selected if they matched the following inclusion criteria: study groups consisted of a minimum of 5 patients, with a minimal age of 18 years, and patients had received a conservative (nonsurgical) treatment for symptoms of ulnar nerve compression at the elbow. All types of conservative treatment were included. Only studies with clearly described outcomes were selected, with at least a distinction between improvement and no improvement.

Exclusion criteria were studies performing animal experiments, cadaver studies, single case reports, or reviews. In ►**Fig. 1**, the selection process is shown. ►**Table 2** provides a summary of the characteristics of the included studies.

Quality Assessment

The quality of the included case–control studies was assessed using the "JBI Critical Appraisal Checklist for case-control studies" and the "JBI Critical Appraisal checklist for case series."[5] These checklists pay attention to selection of the study groups, evaluation of the exposure, and statistical analysis. In the checklist for case–control studies, the comparability of the groups and confounding factors are evaluated. Quality assessment is performed using a score ranging from 0 to 10 points. Studies with a score of 7 to 10 points were considered as high quality, 4 to 6 points as moderate quality, and 0 to 3 as low quality. Two reviewers conducted the quality appraisal. Any disagreements during the process were discussed and resolved by adjudication by a third reviewer.

Data Extraction

Data were independently extracted by two reviewers. The following data were extracted from the studies: total number of patients, gender, affected arm (dominant/nondominant), duration of symptoms until the start of treatment, type of conservative treatment, total duration of treatment, subjective and objective outcome measurements for pain, sensory or motor function improvement after the conservative treatment, advantages and disadvantages described by the authors, complications, and other features. In cases of different interpretations, the results were discussed again by the two reviewers and resolved by involvement of a third reviewer.

Statistical Analysis

The I^2 statistic was determined to measure study heterogeneity. The cutoff value for low, moderate, and high heterogeneity is set at 25, 50, and 75%, respectively.[6] When possible and appropriate, a random-effects model was used to pool proportions of individual studies in the subgroups. This was done for the subgroup injections and splint devices, with the exception of studies reporting no individual response rates. Because I^2 was moderate to high in both subgroups, random-effects models were used for further analyses. Results are presented as mean values or 95% confidence intervals. A p-value of ≤ 0.05 was considered statistically significant. Forest and funnel plots for both subgroup analyses were created for optimal visualization of the results. No additional analyses were done. Statistical analyses were performed using MedCalc for Windows, version 19.3.1 (MedCalc Software, Ostend, Belgium).[7]

Results

Initially, 1,079 studies were identified. A total of 515 duplicates were removed, and the remaining 564 titles and abstracts were screened for suitability. Forty-one studies were selected and the full texts were read. Nineteen papers were included in the final analysis. Screening the reference lists did not provide inclusion of additional studies. The selection process flow diagram with reasons for exclusion is shown in ►**Fig. 1**. Of the included studies, 12 were level IV evidence,[8–19] whereas 7 were level III[20–26] (►**Table 2**). Methodological quality varied among the studies: 16 studies were considered as high quality and 3 studies as moderate quality. Also, 63% ($n = 12$) of the studies did not mention if they were funded, while 32% ($n = 6$) of the studies explicitly stated no funding. One study reported funding, but declared this had no role in collection, analysis,

Table 1 Detailed search methods

	Ovid MEDLINE In-Process and other nonindexed citations, Ovid MEDLINE Daily, Ovid MEDLINE, and Ovid OLD-MEDLINE 1946 to present		Embase 1974 to present		CENTRAL	
Search #	Search	Results	Search	Results	Search	Results
1	Ulnar Nerve.ti,ab,kf.	6,584	Ulnar Nerve.ti,ab, kw.	7,974	Ulnar nerve	1,209
2	Exp Ulnar Nerve Compression Syndromes/	1,053	Cubital tunnel syndrome/	2,583		
3	Exp Nerve Compression Syndromes/	21,972	Exp Nerve Compression Syndromes/	13,300		
4	Cubital Tunnel Syndrome*.ti,ab,kf.	735	Cubital Tunnel Syndrome*.ti,ab,kw.	881	(cubital tunnel syndrome*)	73
5	(Ulnar ADJ5 nerve ADJ5 compress*).ti,ab,kf.	617	(Ulnar ADJ5 nerve ADJ5 compress*).ti, ab,kw.	691	Ulnar near/5 nerve near/5 compress*	22
6	(Ulnar ADJ3 neuropat*). ti,ab,kf. OR (ulnar ADJ3 nerve ADJ3 entrap*).ti, ab,kf	1,322	(Ulnar ADJ3 neuropat*.ti,ab,kw. OR ulnar ADJ3 nerve ADJ3 entrap*).ti,ab, kw.	1,714	Ulnar near/3 neuropat* OR ulnar near/ 3 nerve near/3 entrap*	45
7	Exp Ulnar Neuropathies/	1,681				
8	Exp Compression neuropathy/	8,555	Exp compression/OR neuropathy/	83,947		
9	Exp Elbow/OR elbow.ti, ab,kf.	33,242	Elbow/OR elbow.ti, ab,kw.	43,519	Elbow	4,174
10	9 AND (1 OR 2 OR 3 OR 5 OR 6 OR 7 OR 8)	2,731	9 AND (1 OR 3 OR 5 OR 6 OR 8)	3,653	9 AND (1 OR 5 OR 6)	139
11	4 OR 10	3,135	2 OR 4 OR 10	5,290	4 OR 10	184
12	Exp Conservative Treatment/	2,826	Conservative treatment/	79,796	Conservative next treatment	4,883
13	Exp Splints/	8,696	Exp arm splint/	67		
14	Splint*.ti,ab,kf.	14,464	Splint*.ti,ab,kw.	15,653	Splint*	2,313
15	Surgical casts/	8,688				
16	Cast*.ti,ab,kf.	102,756	Cast*.ti,ab,kw.	120,699	Cast*	15,992
17	Nonoperative.ti,ab,kf. OR non-operative.ti,ab, kf.	15,164	(Nonoperative OR non-operative).ti, ab,kw.	18,895	Nonoperative OR non-operative	1692
18	Nonsurgical.ti,ab,kf. OR non-surgical.ti,ab,kf.	26,613	(Nonsurgical OR non-surgical).ti,ab, kw.	34,956	Non-surgical OR nonsurgical	3,561
19	Brace*.ti,ab,kf.	7,284	Brace*.ti,ab,kw.	9,295	Brace*	1,829
20	Avoiding pressure.ti,ab, kf. OR activity modification.ti,ab,kf.	634	(Avoiding pressure OR activity modification).ti,ab,kw.	762	Avoiding next pressure OR activity next modulation	124
21	Immobilization.ti,ab,kf. OR immobilisation.ti,ab, kf.	51,032	(Immobilization OR immobilization).ti, ab,kw.	57,722	Immobilization OR immobilisation	2891
22	Orthoses.ti,ab,kf OR Orthotic Device*.ti,ab,kf.	3,551	(Orthoses OR Orthotic Device*).ti, ab,kw.	4,737	Orthoses OR Orthotic next Device*	1,276
23	Nerve tap*.ti,ab,kf.	2	Nerve tap*.ti,ab,kw.	2	Nerve tap*	694

Table 1 (*Continued*)

	Ovid MEDLINE In-Process and other nonindexed citations, Ovid MEDLINE Daily, Ovid MEDLINE, and Ovid OLD-MEDLINE 1946 to present		Embase 1974 to present		CENTRAL	
Search #	Search	Results	Search	Results	Search	Results
24	Nerve gliding*.ti,ab,kf.	60	Nerve gliding*.ti, ab,kw.	68	Nerve gliding*	63
25	Segmental joint manipulation*.ti,ab,kf.	1	Segmental joint manipulation*.ti, ab,kw.	1	Segmental joint manipulation*	57
26	Exercise*.ti,ab,kf.	292,975	Exercise*.ti,ab,kw.	393,355	Exercise*	96,994
27	Sliding technique*.ti,ab, kf.	69	Sliding technique*. ti,ab,kw.	107	Sliding next technique	19
28	Neurodynamic mobilization* OR neurodynamic mobilization*.ti, ab,kf.	25	(Neurodynamic mobilization* OR neurodynamic mobilization*).ti, ab,kw.	29	Neurodynamic next mobilization OR neurodynamic mobilisation	85
29	Corticosteroid*.ti,ab,kf.	102,425	Corticosteroid*.ti, ab,kw.	153,079	Corticosteroid*	20,704
30	12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29	510,884	Exp external splint/	377	12 OR 14 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29	126,293
31			Exp arm brace/	132		
32			12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31	708,965		
33	11 AND 29	279	11 AND 29	616	11 AND 29	184

and interpretation of data and in writing of the manuscript.[26] A total of 682 patients, including 684 arms, were followed-up after receiving a treatment for ulnar nerve compression at the elbow. One study included a patient group receiving surgical management, without stating the exact number of patients involved.[25] In studies describing the following parameters, patients had a mean age of 48.7 years, the dominant side was involved in 64% of patients (198 of 313), and the minimal follow-up period was an average of 6.2 months (range: 1–124 months). Six studies included patients with mild-to-moderate symptoms,[10,12,15,17,20,24] while 13 studies included patients with any severity of symptoms.[8,9,11,13,14,16,18,19,21–23,25,26] The most common interventions, from most to least common, included education and activity modification, steroid/lidocaine injection, splinting, physical therapy, pulsed ultrasound (US), or laser therapy. The most commonly reported outcomes included subjective clinical and patient-reported outcomes, such as patient-reported VAS scores, symptoms, questionnaires, and clinical signs, followed by nerve conduction studies and US examination. Two studies only reported subjective outcomes,[10,15] while 17 studies reported on a combination of subjective and objective outcome measurements.[8,9,11–14,16–26] Subgroup meta-analyses were performed on the injection and the splint devices studies. Oskay et al reported that 100% of patients ($n = 7$) had improvement of symptoms after physical therapy with an average follow-up period of 12 months, specifically after neurodynamic mobilization therapy in combination with US therapy.[13] Ozkan et al stated that 69% of the patients ($n = 32$) had improvement of symptoms 3 months after starting US or low-level laser therapy (LLLT).[22] The duration of symptoms was between 5 weeks and 6 months at the start of these physical therapies. Nakamichi et al stated that 59% of arms ($n = 80$) had improvement of symptoms 3 months after education about the pathophysiology and activity modification.[18] Beekman et al and Omejec et al reported that, respectively, 35 and 82% of the arms ($n = 46$ and 67) had improvement of symptoms after an average period of 22,8 months after starting to avoid risky positioning of the affected limb, and Padua et al described that 40% of the arms ($n = 30$) had improvement of

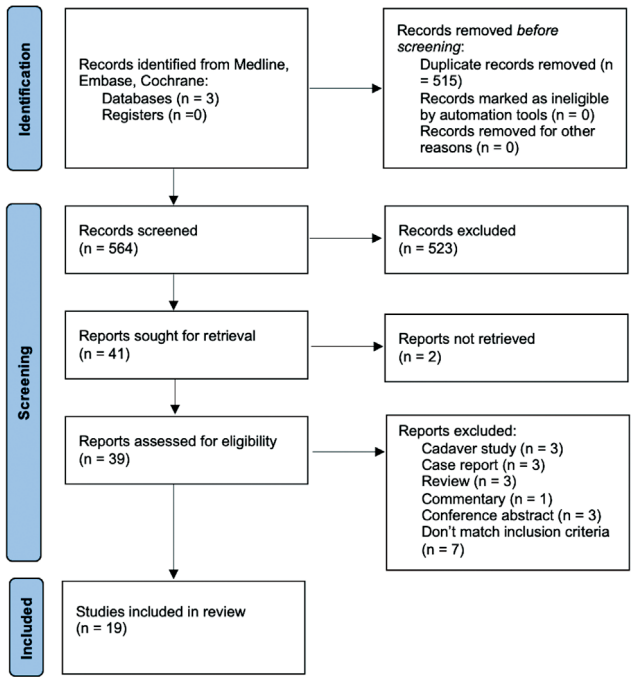

Fig. 1 The selection process following the PRISMA 2020 recommendations.

their symptoms after 6 to 19 months of only giving information about what ulnar nerve entrapment at the elbow is and how to avoid risky positioning.[19,25,26] Beekman et al reported an average duration of symptoms of 3.5 months before the start of activity modification.[25] Omejec et al and Padua et al did not mention the duration of symptoms.[19,26] Study data are presented in ►**Table 3**.

Physical Therapy, Ultrasound, and Laser Therapy

Neurodynamic mobilization in combination with US therapy was reported to be a beneficial therapy for all patients. Oskay et al stated that these therapies are viable options for the treatment of ulnar neuropathy at the elbow.[13] Ozkan et al saw significant improvement in patients after treating them with either US or LLLT.[22] More severely affected patients were pooled in the US group, so they reason that this therapy might be superior to LLLT.

Meta-analysis

Injections

In our meta-analysis of the outcomes of conservative therapy for ulnar nerve compression at the elbow, a statistically significant proportion of patients improved after a steroid/lidocaine injection.

Pooled results of six studies in the injections subgroup showed that 54% of the patients (95% confidence interval [CI], 41–67) improved after an average period of 4.3 months after receiving a steroid/lidocaine injection for ulnar nerve compression at the elbow. The duration of symptoms before injection was 2 to 36 months. The I^2 was 59% (95% CI, 0–83). Forest and funnel plot are shown in ►**Fig. 2**, and detailed calculations are shown in ►**Table 4**.

Splinting

Pooled results of five studies in the splint devices subgroup showed that 89% of the patients (95% CI, 69–99) improved using a splint device for ulnar nerve compression at the elbow for an average period of 18.7 months.[14] I^2 was 92% (95% CI, 84–96). Forest and funnel plot are shown in ►**Fig. 3**, and detailed calculations are shown in ►**Table 4**. The duration of symptoms before starting the usage of a splint was 0.5 to 72 months. All studies used an elbow brace that prevented elbow flexion. Dellon et al, Seror, Shah et al, and Svernlöv et al used a nighttime splint,[14,16,17,24] while Hong et al and Michell and Sesath recommended to wear the splints as much as possible.[15,23] The splints consisted of a variety of materials, including neoprene, polyform, and thermoplastic.[14,23,24] Michell and Sesath designed the Cambridge Ulnar Splint, with a plastic exoskeleton, for their study.[15]

Discussion

In this systematic review, we evaluated available conservative treatment options for ulnar nerve compression at the elbow and reviewed the effectiveness and complications of the options. Of the 1,079 retrieved studies, 19 were eligible for analysis and included a total of 682 patients and 684 cases of ulnar neuropathy at the elbow. Improvement of symptoms was reported in 54% of the cases receiving a steroid/lidocaine injection (95% CI, 41–67). Improvement of symptoms was reported in 89% of the cases using a splint device (95% CI, 69–99).

The results of the subgroup meta-analyses show the proportions of patients with improvement of symptoms, but not how much they improved. The inability to determine the amount of the improvement is due to the wide variety of outcome measures used in the included studies (e.g., subjective clinical and patient-reported outcomes, nerve conduction studies, and US examination).

All the studies included in this systematic review described improvement in symptoms after education, information about avoiding risky positioning of the elbow, or both. Nakamichi et al described this treatment to be effective, inexpensive, and simple, with no contraindications. It can be started immediately after diagnosis.[18] Since there were no control groups in any of these studies, where patients received no information at all, improvement due to the natural course of ulnar neuropathy at the elbow cannot be ruled out.

In our meta-analysis, a statistically significant proportion of patients using a splint device for ulnar nerve compression at the elbow improved. Michell and Sesath presented it to be a comfortable, effective, and cost-effective treatment option.[15] Seror and Svernlöv et al report that even patients with severe and long-lasting symptoms benefited from wearing a splint.[16,24] Hong et al compared wearing a splint with an additional steroid injection and detected no supplementary effect of the injection.[23] This brings us to a curious point where it is the question if the placebo effect or natural course of ulnar nerve compression at the elbow might not be inadequate.

Table 2 Summary of characteristics of studies included

#	Authors and year	Title	Journal	Country	Type of study	Number of patients receiving conservative treatment	Level of evidence	Funding or conflict of interest	Methodological quality assessment
Injections:									
1	Alblas et al, 2012[8]	Injection with corticosteroids (ultrasound guided) in patients with an ulnar neuropathy at the elbow, feasibility study	European Journal of Neurology	The Netherlands	Case series, prospective	8	IV	NM	High
2	Chen et al, 2020[20]	Perineural dextrose and corticosteroid injections for ulnar neuropathy at the elbow: a randomized double-blind trial	Archives of Physical Medicine & Rehabilitation	China	Case–control, prospective	33	III	No	High
3	Choi et al, 2015[9]	Clinical implications of real-time visualized ultrasound-guided injection for the treatment of ulnar neuropathy at the elbow: a pilot study	Annals of Rehabilitation Medicine	Korea	Caser series, prospective	10	IV	No	High
4	Gronbeck et al, 2021[10]	Ultrasound-guided cubital tunnel injection: a review and exploration of utility as a diagnostic aid in mild or nonclassic cubital tunnel patients	Techniques in Orthopaedics	United States	Case series, retrospective	63	IV	NM	High
5	Pechan and Kredba, 1980[11]	Treatment of cubital tunnel syndrome by means of local administration of cortisonoids. II. Long-term follow-up	Acta Universitatis Carolinae, Medical	Czech Republic	Case series, prospective	14	IV	NM	Moderate
6	Rampen et al, 2011[12]	Ultrasound-guided steroid injection to treat mild ulnar neuropathy at the elbow	Muscle & Nerve	The Netherlands	Case series, prospective	7	IV	NM	High

(*Continued*)

Table 2 (*Continued*)

7	vanVeen et al, 2015[21]	Corticosteroid injection in patients with ulnar neuropathy at the elbow: a randomized, double-blind, placebo-controlled trial	Muscle & Nerve	The Netherlands	Case–control, prospective	30	III	NM	High
Physical therapy:									
8	Oskay et al, 2010[13]	Neurodynamic mobilization in the conservative treatment of cubital tunnel syndrome: long-term follow-up of 7 cases	Journal of Manipulative & Physiological Therapeutics	Turkey	Case series, prospective	7	IV	No	Moderate
9	Ozkan et al, 2015[22]	New treatment alternatives in the ulnar neuropathy at the elbow: ultrasound and low-level laser therapy	Acta Neurologica Belgica	Turkey	Case–control, prospective	32	III	No	High
Splint devices:									
10	Dellon et al, 1993[14]	Nonoperative management of cubital tunnel syndrome: an 8-year prospective study	Neurology	United States	Case series, prospective	121	IV	NM	High
11	Hong et al, 1996[23]	Splinting and local steroid injection for the treatment of ulnar neuropathy at the elbow: clinical and electrophysiological evaluation	Archives of Physical Medicine & Rehabilitation	United States	Case–control, prospective	10	III	No	High
12	Michell and Sesath, 2020[15]	Feasibility trial of treatment of ulnar neuropathy at the elbow using a specifically designed splint	JCR: Journal of Clinical Rheumatology	United Kingdom	Case series, prospective	15	IV	NM	Moderate

Table 2 (*Continued*)

13	Seror, 1993[16]	Treatment of ulnar nerve palsy at the elbow with a night splint	Journal of Bone & Joint Surgery	France	Case series, prospective	22	IV	NM	High
14	Shah et al, 2013[17]	Outcomes of rigid night splinting and activity modification in the treatment of cubital tunnel syndrome	Journal of Hand Surgery	United States	Case series, prospective	19	IV	NM	High
15	Svernlöv et al, 2009[24]	Conservative treatment of the cubital tunnel syndrome	Journal of Hand Surgery	Sweden	Case–control, prospective	51	III	NM	High
Other:									
16	Beekman et al, 2004[25]	Ulnar neuropathy at the elbow: follow-up and prognostic factors determining outcome	Neurology	Netherlands	Case– control, prospective	NA	III	NM	High
17	Nakamichi et al, 2009[18]	Patient education for the treatment of ulnar neuropathy at the elbow	Archives of Physical Medicine & Rehabilitation	Japan	Case series, prospective	77	IV	No	High
18	Omejec and Podnar, 2018[26]	Long-term outcomes in patients with ulnar neuropathy at the elbow treated according to the presumed etiology	Clinical Neurophysiology	Slovenia	Case– control, prospective	67	III	Yes	High
19	Padua et al, 2002[19]	Natural history of ulnar entrapment at elbow	Clinical Neurophysiology	Italy	Case series, retrospective	30	IV	NM	High

Abbreviations: NA, no information available; NM, not mentioned.

Table 3 Summary of data in studies included in the systematic review

#	Authors and year	No. of patients in conservative group/no. of cases	Males (no. [%])/females (no. [%])	Mean age in years (range)	Severity of the included cases[a]	Mean FU in years (range)	No. of cases improved (%)/no. of patients not improved (%)
Injections							
1	Alblas et al, 2012[8]	8/9	4 (50)/4 (50)	53 (43–67)	U	0.25 (NA)	5 (56)/4 (44)
2	Chen et al, 2020[20]	33/33	11 (33)/22 (67)	56 (32–77)	Mild-to-moderate	0.5 (NA)	17 (52)/16 (48)
3	Choi et al, 2015[9]	10/10	7 (70)/3 (30)	63 (57–58)	U	0.1 (NA)	NA (significant drop in VAS)
4	Gronbeck et al, 2021[10]	NA/56	NA	47 (NA)	Mild	NA (0.1–0.25)	38 (68)/18 (32)
5	Pechan and Kredba, 1980[11]	14/22	6 (43)/8 (57)	41 (25–65)	Mild	1.2 (0.5–NA)	14 (64)/8 (36)
6	Rampen et al, 2011[12]	7/7	6 (86)/1 (14)	43 (32–54)	Mild	0.13 (NA)	4 (57)/3 (43)
7	vanVeen et al, 2015[21]	30/30	18 (60)/12 (40)	56 (29–91)	U	0.25 (NA)	9 (30)/21 (70)
Physical therapy:							
8	Oskay et al, 2010[13]	7/7	NA	NA (35–70)	U	1.0 (NA)	7 (100)/0 (0)
9	Ozkan et al, 2015[22]	32/32	16 (50)/16 (50)	44 (NA)	U	0.25 (NA)	22 (69)/10 (31)
Splint devices:							
10	Dellon et al, 1993[14]	121/121	23 (19)/98 (81)	44 (15–72)	U	4.9 (1.0–10.3)	85 (70)/36 (30)
11	Hong et al, 1996[23]	10/12	10 (100)/0 (0)	59 (37–70)	U	0.5 (NA)	NA (significant improvement in symptoms)
12	Michell and Sesath, 2020[15]	15/15	4 (27)/11 (73)	41 (21–84)	Mild-to-moderate	0.15 (0.13–0.4)	11 (73)/4 (27)
13	Seror, 1993[16]	22/22	12 (55)/10 (45)	52 (39–81)	U	0.9 (0.3–2.5)	22 (100)/0 (0)
14	Shah et al, 2013[17]	19/24	8 (42)/11 (58)	43 (21–72)	Mild-to-moderate	2.0 (1.3–2.7)	21 (88)/3 (12)
15	Svernlöv et al, 2009[24]	51/51	24 (47)/27 (53)	43 (17–72)	Mild-to-moderate	0.5 (NA)	51 (100)/0 (0)
Other:							
16	Beekman et al, 2004[25]	NA/46	NA	51 (39–60)	U	1.2 (6–NA)	16 (35)/30 (65)
17	Nakamichi et al, 2009[18]	77/80	56 (73)/21 (27)	52 (19–77)	U	NA (3–NA)	59 (74)/21 (26)
18	Omejec and Podnar, 2018[26]	67/67	33 (49)/34 (51)	47 (19–75)	U	2.4 (2.2–3.4)	55 (82)/12 (18)
19	Padua et al, 2002[19]	27/30	11 (41)/16 (59)	57 (32–76)	U	NA (0.5–1.6)	12 (40)/18 (60)

Abbreviations: FU, follow-up; NA, no information available; U, unspecified; VAS, visual analog scale.
[a]The severity of the included cases was defined by the authors of the included studies.

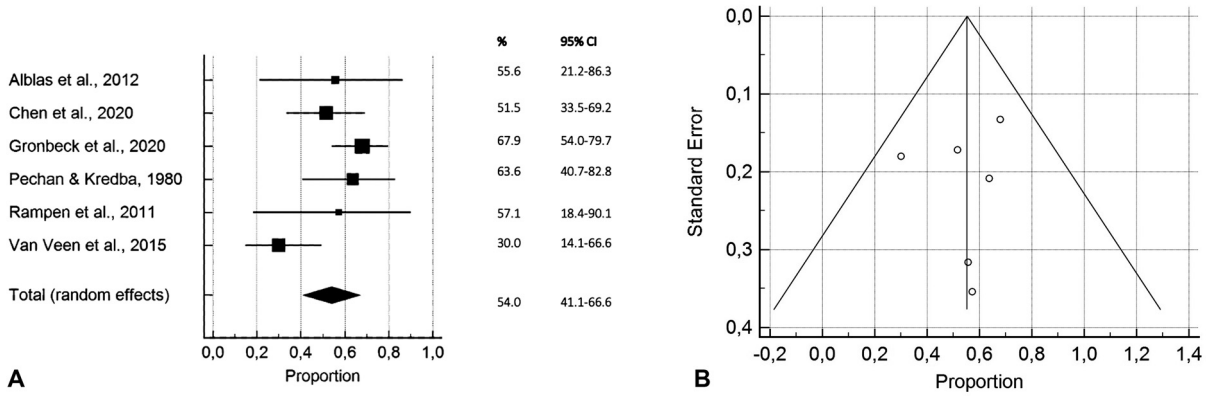

Fig. 2 Forest plot (**A**) and funnel plot (**B**) showing pooled results of overall symptomatic improvement in proportions of improved patients in the injections subgroup with 95% CIs per included study.

Table 4 Exact calculations and tests for heterogeneity corresponding with ►**Figs. 2** and **3**

Author and year	Sample size (no. of cases)	Proportion (%)	95% CI	Weight (%) random effects
►**Fig. 2**: pooled results of overall symptomatic improvement in proportions of improved patients in the injections subgroup				
Alblas et al, 2012[8]	9	55,556	21,201–86,300	11.02
Chen et al, 2020[20]	33	51,515	33,544–69,204	19.93
Gronbeck et al, 2021[10]	56	67,857	54,036–79,715	23.07
Pechan and Kredba, 1980[11]	22	63,636	40,658–82,802	17.17
Rampen et al, 2011[12]	7	57,143	18,405–90,101	9.51
vanVeen et al, 2015[21]	30	30,000	14,735–49,396	19.30
Total (random effects)	157	54,009	41,135–66,617	100.00
►**Fig. 3**: pooled results of overall symptomatic improvement in proportions of improved patients in the splint devices subgroup				
Dellon et al, 1993[14]	121	70,248	61,262–78,215	21.77
Michell and Sesath, 2020[15]	15	73,333	44,900–92,213	18.30
Seror, 1993[16]	22	100,000	84,563–100,000	19.38
Shah et al, 2013[17]	24	87,500	67,639–97,344	19.59
Svernlöv et al, 2009[24]	51	100,000	93,022–100,000	20.96
Total (random effects)	235	89,000	69,729–99,128	100

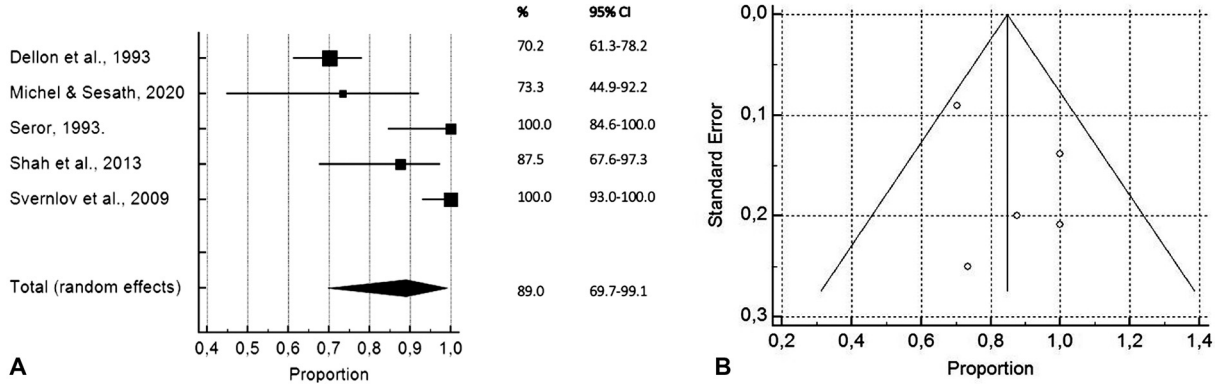

Fig. 3 Forest plot (**A**) and funnel plot (**B**) showing pooled results of overall symptomatic improvement in proportions of improved patients in the splint devices subgroup with 95% CIs per included study.

A major flaw of the study is the lack of preoperative clinical data. The severity of the clinical situation is not exactly known. Six studies only included patients with mild-to-moderate symptoms, while 13 studies included patients with any severity of symptoms. However, it is possible that patients with more severe symptoms were offered or opted for surgery earlier. Different patient populations are compared, and different treatment durations, follow-up periods, compliances, and outcome measures are reported in the included studies. Duration of symptoms in the included studies is not clearly stated, so no conclusion could be drawn on the natural course of ulnar neuropathy at the elbow.

It cannot be denied that bias might be introduced especially due to the lack of a proper control group and small samples. Dropouts in the included studies are likely to be patients who are experiencing no effect from conservative treatment options, so effectiveness of the investigated treatment could be overrated in some of the included studies. This might be overcome by developing a proper randomized clinical trial comparing some kind of conservative treatment with no treatment.

Conservative management for ulnar neuropathy at the elbow seems to improve symptoms in up to 9 out of 10 patients. Both lidocaine/steroid injections and splint devices gave a significant improvement in symptoms and are suitable options for patients who refuse an operative procedure or need a bridge to this treatment. Physical therapy also seems to be a promising option but needs to be investigated further in larger samples to draw any conclusions on the overall effectiveness. Also, the education and activity modification gave a positive effect on the symptoms and form a simple way to start any treatment for ulnar neuropathy at the elbow. In cases where surgical treatment is not applicable to patients due to comorbidities, it is tempting to advise education in combination with activity modification. This might be followed or combined with further splinting. However, the limitations of this study should be taken into consideration.

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Authors' Contributions
T.N.: conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft, writing – review and editing.
M.S.v.d.W.: Conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft, writing – review and editing.
E.P.H.: Conceptualization, methodology, writing – original draft, writing – review and editing.
N.J.S.: Data curation, formal analysis, investigation, methodology, writing – original draft.
E.T.W.: Conceptualization, project administration, supervision, writing – review and editing.
R.H.M.A.B.: Conceptualization, investigation, methodology, project administration, resources, supervision, writing – review and editing.

Conflict of Interest
None declared.

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