Is early active mobilization after open TFCC repair non-inferior to longer immobilization? A propensity score matching study

Masterthesis

Physiotherapy Science

Program in Clinical Health Sciences

Utrecht University

Name student:	S.T. (Sebastiaan) Peters
Student number:	3852830
Date:	June 22nd, 2023
Internship supervisor(s):	Dr. J.S. Teunissen, Dr. R.M. Wouters, Prof. Dr. R.W. Selles
Internship institute:	Hand Wrist Study Group, Department of Plastic and Reconstructive Surgery and Rehabilitation Medicine, Hand Surgery and Rehabilitation, Erasmus MC Rotterdam, Rotterdam, The Netherlands
Lecturer/supervisor Utrecht University:	Dr. M.F. Pisters

"ONDERGETEKENDE

Sebastiaan Tjènne Peters,

bevestigt hierbij dat de onderhavige verhandeling mag worden geraadpleegd en vrij mag worden gefotokopieerd. Bij het citeren moet steeds de titel en de auteur van de verhandeling worden vermeld."

Examiner

Dr. M.F. Pisters

Assessors:

Dr. R.M. Wouters

Dr. M.A. Timmer

Masterthesis, Physical Therapy Sciences, Program in Clinical Health Sciences, Utrecht University, Utrecht, 2023

ABSTRACT

Background

Following surgical repair of the triangular fibrocartilage complex (TFCC), a rehabilitation program is usually advised. Early active mobilization may theoretically promote stronger ligament healing with fewer limitations during immobilization, more convenience during early rehabilitation, and a faster return to work than longer immobilization. However, no evidence for early active mobilization on these outcomes is available, and in theory, shorter immobilization might also lead to worse pain and hand function outcomes.

Aim

The aim of this study was to investigate whether an early active mobilization protocol after open TFCC repair is non-inferior to long-term wrist immobilization at 3 months after surgery in terms of pain and hand function.

Methods

This retrospective, multicenter cohort study with propensity score matching (PSM) compared early active mobilization (active rotation within the first week) with long-term immobilization (active rotation after 6 weeks), using ongoing routinely collected data collected between March 2017 and March 2022 with a year follow-up. Patients in both groups wore a long wrist splint 24 h/d for 6 weeks. The Patient Rated Wrist/Hand Evaluation (PRWHE) was used to measure pain and hand function at 3 months. Secondary outcomes were PRWHE at 12 months; Patient-Specific Function Scale, grip strength, and active range of motion at 3 and 12 months; and return to work and complications within the first year.

Results

Of the 197 eligible patients, 104 could be matched using PSM and were included. PRWHE scores following an early active mobilization protocol were non-inferior compared with a long-term immobilization protocol. Furthermore, non-inferiority was found in all secondary outcomes on pain, hand function, AROM, and grip strength. Additionally, no differences were found in return to work and complication rate.

Conclusion and key findings

In conclusion, the findings of this study suggest that an early active mobilization protocol is non-inferior to longer immobilization in terms of pain and hand function, and it does not lead to more complications. A future randomized clinical trial using an adequate sample size is required to confirm these findings.

Keywords: Triangular fibrocartilage complex; Open reinsertion; Rehabilitation; Early active mobilization; Wrist

INTRODUCTION

The triangular fibrocartilage complex (TFCC) is the main stabilizer of the distal radioulnar joint.[1–3] Traumatic disruption may lead to instability of the distal radioulnar joint and is a common cause of ulnar-sided wrist pain. The onset of symptoms can be presented months or years after the initial trauma. Problems with push-ups, decreased grip strength, and impaired hand function are commonly associated with TFCC lesions.[4–8] These symptoms may cause a reduction in participation in daily activities such as work or sports.

Initial management of TFCC lesions commonly consists of splinting and wrist exercises.[3,6,9] If symptoms persist or reoccur, surgical repair of the TFCC can be considered.[3,6,9–12] After surgical repair, a rehabilitation program is usually advised.[13–15] While previous studies have focused on comparing outcomes between open and arthroscopic TFCC repair, little attention has been paid to the rehabilitation program.[15,16] There is limited evidence and many variations on this topic, primarily based on protocols described in surgical procedure research.[5,6,11,12,15,17–20] In these studies, the immobilization after surgery varies between 6 and 8 weeks[5,6,11,12,17–20], and active range of motion (AROM) towards pronation and supination initially starts between 4 and 6 weeks.[5,6,11,17–20] Within these protocols, AROM towards pronation and supination will subsequently be initiated once sufficient ligament strength is reached based on the different phases of soft tissue healing. Decreasing the risk of complications such as ligament re-rupture.[5,15,21]

However, Feitz et al.[6] suggested that the rehabilitation protocol can incorporate early active mobilization toward supination. Recent studies have shown that initiating early active motion and stress potentially results in stronger ligament healing, as, for instance, observed in anterior cruciate ligament (ACL) surgery.[15,21,22] Biomechanically, the TFCC comprises well-vascularized ligaments with a high potential for healing following surgery.[12,15,23,24] Therefore, early active rotation may theoretically promote stronger ligament healing, comparable to ACL surgery.[15,21,22] Hypothetically, this might lead to fewer limitations in daily life during immobilization, more convenience during early rehabilitation, and a faster return to work (RTW). However, no evidence for early active rotation on these outcomes is available, and in theory, shorter immobilization might also lead to worse pain and hand function outcomes because it can potentially disrupt the healing process through overload, increasing the risk of tendon irritation, continued instability, or even re-rupture. Therefore, more research is needed to ensure that early active mobilization after TFCC repair is safe and results in at least comparable pain and hand function outcomes.

Therefore, the aim of this study was to investigate whether an early active wrist rotation protocol after open TFCC repair is non-inferior to long-term wrist immobilization 3 months after surgery in terms of pain and hand function. The secondary outcomes in this study include pain and hand function at 12 months, AROM and grip strength at 3 and 12 months, and RTW and complications within the first year after surgery.

METHODS

Study design and setting

This multicenter retrospective cohort study uses propensity score matching (PSM) and is based on ongoing routinely collected data of patients who underwent open TFCC repair. The study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology statement.[25] By stratifying patients treated in two different periods with different postoperative guidelines, we compared early active mobilization toward rotation with 6 weeks of immobilization. The Medical Research Ethical Committee of the Erasmus MC Rotterdam approved this study, and written informed consent was obtained from all patients.

Data were collected on a consecutive cohort of patients who underwent open TFCC repair between March 2017 and March 2022 with a one-year follow-up at Xpert Clinics and Xpert Hand Therapy, The Netherlands, a multicenter clinic specialized in hand surgery and therapy. All hand surgeons at Xpert Clinics are certified by the Federation of European Societies for Surgery of the Hand or fellowship trained, with experience levels ranging from III to V.[26] After their first consultation with a hand surgeon, all patients who underwent TFCC repair were invited to be part of a routine outcome measurement using GemsTracker electronic data capture tools.[27] Upon agreement, they receive secure web-based questionnaires before and at 3 and 12 months after surgery. In addition, AROM and grip strength measurements are conducted by trained hand therapists before and at 3 and 12 months after surgery. A detailed description of the research setting of our study group has been reported previously.[28,29]

Participants

Patients were eligible for inclusion if they (1) were above eighteen years old at the time of surgery and (2) participated in our rehabilitation program after surgery. Patients were excluded if they (1) underwent a major concomitant procedure (e.g., ulnar shortening, Brunelli procedure, osteotomy of the radius, and extensor carpi ulnaris loop), (2) did not complete the Patient Rated Wrist/Hand Evaluation (PRWHE) questionnaire before surgery, or (3) did not complete PRWHE questionnaire at 3 and 12 months after surgery.

Surgical procedure

Open TFCC repair surgery was performed under regional axillary or supraclavicular block; all surgeons used their preferred method for open TFCC repair. Most surgeons used the procedure outlined by Garcia-Elias et al.[13] consists of a Bruner incision of the fifth compartment's dorsal and volar sheaths. Foveal reattachment was obtained by reinsertion of the cartilage disc to the distal ulna with a bone anchor (MITEK; Raynham, Massachusetts, USA; JuggerKnot Soft Anchor; Zimmer Biomet, Warsaw, Indiana, USA). Before insertion of the bone anchor, the surface of the cartilage of the distal ulna was roughened with a rongeur or dental hook to facilitate adhesion formation and reinsertion.[6,13,30]

Rehabilitation

For both groups, the routine postoperative immobilization protocol consisted of a double-slab Plaster-of-Paris cast for 3-5 days, followed by a long below-elbow volar thermoplastic wrist splint that was worn 24 h/d (an above elbow Munster splint was used if requested by the surgeon before October 2020) for 6 weeks, allowing some rotation during immobilization.[31] After 6 weeks, the splint was phased out and worn protectively until 12 weeks. Patients in both groups were offered postoperative therapy at our clinic 2-3 times per week and home exercises (6-8x per day) immediately following surgery, aiming to improve wrist and finger AROM and wrist coordination, strength, and stability. Tendon-gliding exercises were started immediately in both groups, and after 2 weeks, sutures were removed, initiating scar treatment.

Longer immobilization group

In the longer immobilization group, active mobilization exercises toward wrist flexion and extension were initiated after 2 weeks. While active mobilization exercises for wrist rotation and wrist exercises for coordination, strength, and stability were started after 6 weeks.

Early active mobilization group

In the early active mobilization group, active mobilization exercises towards flexion, extension, and supination were initiated until 30° within the first week. After 2 weeks, full wrist flexion and extension exercises were initiated, while supination exercises were initiated until 50° of rotation. Exercises in full supination and pronation until 30° were initiated after 4 weeks, while exercises with full pronation were initiated at 6 weeks. Additionally, wrist exercises for coordination were started after 4 weeks and wrist exercises for strength and stability were started after 6 weeks.

In both groups, if there was a delay in the AROM of wrist rotation, passive mobilization techniques were initiated during therapy sessions after 3 months. *Table 1* summarizes the entire postoperative rehabilitation protocols of both groups.

Because of the observational design of this study, the postoperative treatment was not completely standardized. However, the hand therapists carried out the same protocolized postoperative regimen following strict guidelines. Before October 2020, the rehabilitation protocol with longer immobilization was followed, while the rehabilitation protocol with early active mobilization was introduced in October 2020. All hand therapists were informed by all communication applications when the new postoperative rehabilitation protocol was introduced. To ensure that the new rehabilitation protocol was adopted, a 4-month washout period was created. Consequently, patients were included in the longer immobilization group from March 2017 to June 2020 and in the early active mobilization intervention group from November 2020 to March 2022. We manually reviewed all medical records to ensure adherence to the prescribed postoperative protocol. A more than 2 weeks deviation from the suggested postoperative protocol was considered non-compliance.

Table 1. Postoperative rehabilitation protocols

	Longer immobilization group (before October 2020)		**Early active mobilization group (since October 2020)**
Day 0	-A double-slab Plaster-of-Paris cast is applied after surgery -Start TGE fingers and thumb	Day 0	-A double-slab Plaster-of-Paris cast is applied after surgery -Start TGE fingers and thumb
Week 1-2	-(Day 3-5) Removal of bandage and plaster cast -(Day 3-5) Long below elbow thermoplastic wrist splint (day and night) or above elbow Munstersplint if requested by the surgeon -Start AROM fingers and thumb (TGE, eventually PROM) -(Day 10-14) Suture removal and initiation scar management	Week 1-2	-(Day 3-5) Removal of bandage and plaster cast -(Day 3-5) Long below-elbow thermoplastic wrist splint (day and night) -Start AROM fingers and thumb (TGE, eventually PROM) -Start AROM supination from neutral until 30° -Start AROM wrist flexion and extension until 30° -(Day 10-14) Suture removal and initiation scar management *Warning: no exercises for pronation*
Week 3-4	-Optimizing ROM fingers and thumb (TGE, eventually PROM) -Start AROM wrist flexion/extension *Warning: restrained with max flexion*	Week 3-4	-Optimizing ROM fingers and thumb (TGE, eventually PROM) -Full AROM wrist flexion and extension -AROM supination up to 50° *Warning: no exercises for pronation*
Week 5-6	-Intensifying AROM/PROM fingers -Intensifying AROM wrist flexion and extension -In the case of above elbow Munstersplint, switch to a long below-elbow thermoplastic wrist splint *Warning: no exercises for pronation and supination*	Week 5-6	-Intensifying AROM/PROM fingers -Intensifying AROM wrist flexion and extension -Start AROM radial and ulnar deviation up to 20° -Full AROM supination -Start AROM pronation up to 30° -Start wrist exercises for coordination -Phase-out splint, wearing policy protective *Warning: no intensive endpoint forearm mobilization; No heavy load bearing*
Week 7-12	-Start AROM supination and pronation -Start wrist exercises for coordination, strength, and stability -Increase load bearing and functionality -Phase-out orthosis, wearing policy protective *Warning: no intensive endpoint forearm mobilization; No heavy load bearing*	Week 7-12	-Full AROM supination and pronation - Start wrist exercises for strength and stability -Increase load bearing and functionality -Phase-out orthosis, wearing policy protective *Warning: no intensive endpoint forearm mobilization; No heavy load bearing*
Month 3-6	-Intensify range of motion wrist/forearm -Phase-out orthosis during load-bearing activities -Optimizing strength, stability, load bearing, and functionality	Month 3-6	-Intensify range of motion wrist/forearm -Phase-out orthosis during load-bearing activities -Optimizing strength, stability, load bearing, and functionality

TGE – Tendon gliding exercises; AROM – Active range of motion; PROM – Passive range of motion; ROM – Range of motion

Variables and data sources/measurements

Demographic variables such as age, sex, type of work, symptom duration, treatment side, and hand dominance were collected routinely. We manually reviewed the medical records to collect data on initial management, cointerventions, location of the tear, complications, and whether the patient and hand therapist adhered to the suggested postoperative protocol at our institution.

Patient-reported pain and hand function

The primary outcome pain and hand function at 3 months was measured with the Patient Rated Wrist/Hand Evaluation (PRWHE).[32] The PRWHE is a validated questionnaire comprising fifteen questions; five for pain and ten for hand function. The total score ranges from 0 (“no pain or dysfunction”) to 100 (“severe pain or dysfunction”), with pain and function subscales ranging from 0 ("no pain or dysfunction") to 50 ("severe pain or dysfunction").[33] Additionally, the Patient-Specific Functional Scale (PSFS) was used to measure individualized patient-reported functional limitations. Patients completed the PSFS by identifying and scoring three to five activities they could not perform or had difficulty with due to their condition. Activities were scored on an 11-point scale, with 0 representing “unable to perform” and 10 representing “able to perform at prior-disease level”.[34] Using the mean of item scores, the PSFS is a valid questionnaire for within and between-group comparisons.[35]

AROM and grip strength

AROM in degrees was measured with a goniometer following the International Consortium for Health Outcome Measurement (ICHOM) guidelines.[36] Wrist flexion, ulnar deviation, and pronation were reported as positive values, while wrist extension, radial deviation, and supination, as negative. Grip strength was measured using an E-LINK Jamar-Style dynamometer (Biometrics, Newport, UK); the three trials' mean score was utilized as Mathiowetz et al. described.[37]

Return to work

RTW was measured with a self-developed return-to-work questionnaire at 6 weeks, 3, 6, and 12 months within the subgroup of patients who had paid labor before surgery (*Appendix 1*). RTW was defined as the first time (in weeks) after surgery that the patient performed their original work for at least 50% of the contractual hours. This percentage was chosen since Dutch labor laws require patients to be able to perform less than 50% of their usual work to be allowed any form of compensation.[38,39]

Complications

Complications were scored following the ICHOM Complications in Hand and Wrist Conditions tool (ICHAW).[40] This tool classifies complications within 12 months after surgery into different grades (I-III) based on the required treatment. As suggested by Hoogendam et al.[41], grade I was defined as an “adverse protocol deviation”, and grade II and III as complications.

Sample size

A priori power analysis is different in noninferiority studies using a noninferiority margin, which is a predefined threshold representing the maximum allowable difference between two treatments. It has been described that defining the noninferiority margin should be based on clinical judgment and statistical reasoning.[42,43] We used, similar to Tsehaie et al.[42], a conventional small-to-medium effect size of 0.35, as defined by Cohen[44] as a noninferiority margin, resulting in a total sample of 82 patients (41 per group) for an F-test with a power of 0.80 (α 0.05). Due to the nature of PSM, part of the patients will not be matched and thereby excluded from the analysis. To account for this, we, similarly to Tsehaie et al.[42] doubled the sample size. Therefore, a minimal total sample size of 164 patients was needed.

Statistical analysis

We used PSM to compare both interventions while adjusting for potential covariates.[45–47] We used logistic regression to estimate propensity scores, in which treatment status (in this case, the type of postoperative rehabilitation regime) is regressed on baseline characteristics.[46–48] We used the baseline characteristics age, sex, dominant side treated, type of work, duration of symptoms, and PRWHE total score as covariates based on the factors reported in the literature as prognostic factors of PRWHE score and time till RTW following open TFCC repair.[39,49] Subsequently, we used the propensity scores to match patients on a one-to-three basis using a nearest-neighbor algorithm with a matching tolerance width of 0.1 SD of the logit of the propensity score.[46,48] To examine whether the matching improved the balance between the matched treatment groups, between-group differences were analyzed using standardized mean differences (SMD). If the SMD was less than 0.2, it was considered a small difference between the matched treatment groups.

We used linear mixed models to compare the change of repeatedly measured outcomes over time. The time point, treatment group, and interaction term between the time point and treatment group were used as the fixed effect, while the patient was used as the random effect. Estimated Marginalized Means, including a 95% confidence interval (CI), were calculated for each time point and compared post hoc. Assumptions were checked using residual plots and normal probability plots. Furthermore, we performed a Fisher's exact test to study complication differences. An inverted Kaplan-Meier survival analysis was conducted within the subgroup of patients who had paid labor before surgery to estimate the cumulative RTW within the first year following surgery and calculate the median time until RTW. In addition, a Logrank test was used to compare between-group differences in RTW. Loss to follow-up will be addressed by censoring the patient.[50]

Noninferiority was considered if one bound of the 95% CI lies outside the noninferiority margin but an effect size of 0 lies within the other bound. Equality was considered if the 95% CI lies within the negative and positive noninferiority margins. A conventional small-to-medium effect size of 0.35 was used as a noninferiority margin.[42,43]

Missing data were not imputed, as this does not provide additional value to linear mixed models.[51] We performed a Little's test to investigate whether PRWHE scores at 3 and 12 months were missing completely at random.[52] Additionally, we performed a non-responders analysis using independent t-tests, chi-square tests, and a Kruskal-Wallis test to test for differences in demographic variables and PRWHE scores at intake between patients who completed the PRWHE at 3 and 12 months (responders) and patients who did not (non-responders). To analyze the differences between responders and non-responders, we used SMDs.

For all analyses, a p-value ≤ 0.05 was considered significant. Statistically significant P-values of secondary analyses should be interpreted cautiously as multiple testing increases the probability of false positive results. R statistical software (R Project for Statistical Computing, Austria) was used to perform all analyses.

Table 2. Baseline characteristics before and after propensity score matching

	All patients			Matched patients		
	Early active mobilization group	**Longer immobilization group**	**SMD**	**Early active mobilization group**	**Longer immobilization group**	**SMD**
n	32	163		28	76	
Age in years, mean (SD)	45.16 (14.40)	40.03 (13.18)	0.371	42.71 (13.41)	40.78 (14.00)	0.141
Sex, male (%)	10 (31.2)	48 (29.4)	0.039	7 (25.0)	23 (30.3)	0.118
Duration of symptoms in months, median (IQR)	6.00 (3.88-12.00)	9.00 (5.00-12.50)	0.144	6.00 (3.75-9.75)	8.50 (5.00-12.00)	0.027
Type of work, n (%)			0.444			0.232
Not working (including retired/unable to work)	8 (25.0)	19 (11.7)		5 (17.9)	11 (14.5)	
Light physical work	12 (37.5)	69 (42.3)		11 (39.3)	37 (48.7)	
Moderate physical work	10 (31.2)	49 (30.1)		10 (35.7)	21 (27.6)	
Heavy physical work	2 (6.2)	26 (16.0)		2 (7.1)	7 (9.2)	
Dominant side not treated, n (%)	15 (46.9)	57 (35.0)	0.244	12 (42.9)	32 (42.1)	0.015
PRWHE total score at intake, mean (SD)	60.38 (15.34)	60.75 (17.33)	0.023	61.25 (14.72)	61.41 (18.38)	0.009
PRWHE pain score at intake, mean (SD)	32.31 (7.43)	33.12 (8.69)	0.099	32.25 (7.75)	32.61 (9.88)	0.040
PRWHE function score at intake, mean (SD)	28.06 (10.32)	27.63 (10.54)	0.041	29.00 (9.29)	28.80 (10.50)	0.020
Arthroscopy findings, n (%*)			0.310			0.264
Central tear	2 (9.1)	8 (8.0)		2 (9.5)	4 (9.5)	
Lateral tear or foveal detachment	17 (77.3)	71 (71.0)		16 (76.2)	29 (69.0)	
Distal avulsion	0 (0.0)	4 (4.0)		0 (0.0)	1 (2.4)	
Radial tear	3 (13.6)	17 (17.0)		3 (14.3)	8 (19.0)	

SMD – standardized mean differences; SD – standard deviation; IQR – interquartile range; PRWHE – Patient Rated Wrist/Hand Evaluation; * – percentage of the arthroscopic findings

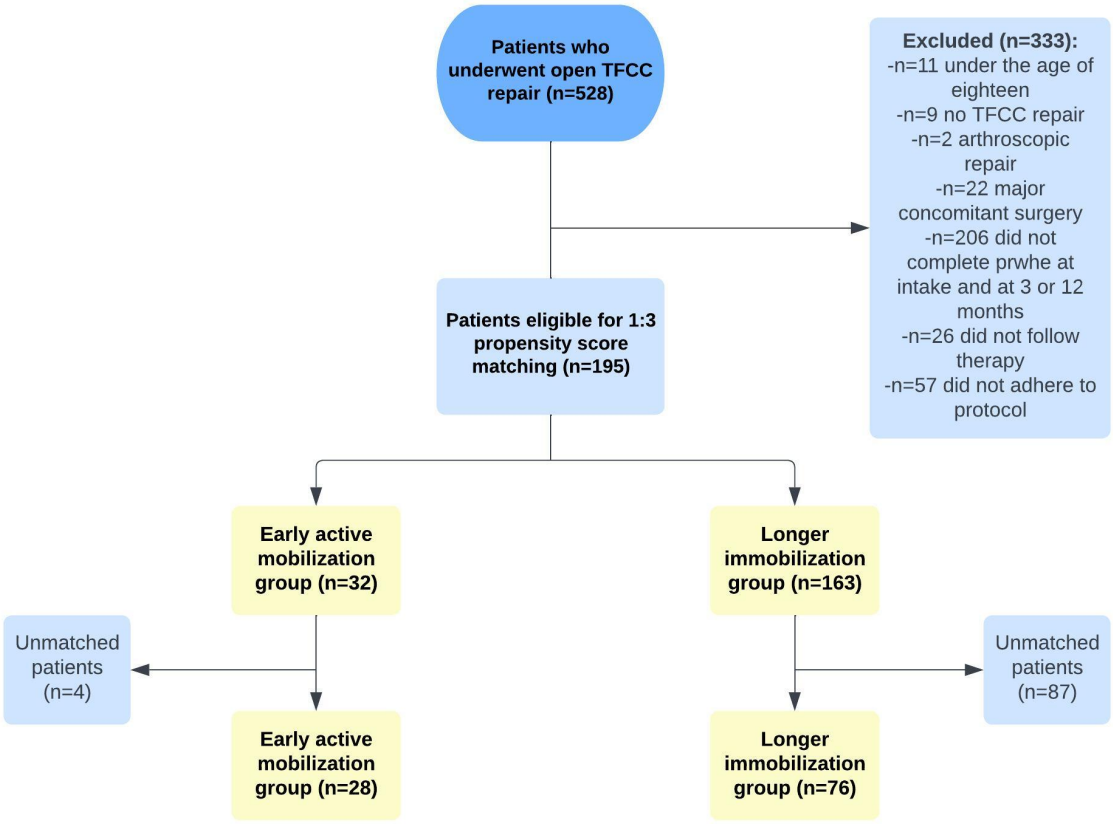

Figure 1. Flowchart of this study. *TFCC – Triangular fibrocartilage complex; PRWHE – Patient Rated Wrist/Hand Evaluation*

RESULTS

A total of 528 patients who underwent TFCC repair were identified between March 2017 and June 2020 and between November 2020 and March 2022. After applying the eligibility criteria, 195 patients were found to be eligible for inclusion. Due to time constraints, only 32 patients in the early active mobilization group were eligible for inclusion. After matching, 28 patients were in the early active mobilization group and 76 in the longer immobilization group (*Figure 1*). The baseline characteristics before and after matching are shown in *Table 2*. After matching, all SMDs were below 0.2, except for the type of work (SMD = 0.232) and the location of the tear within the arthroscopy findings (SMD = 0.264). Within the non-responder analyses, all SMDs between responders and non-responders were below 0.2, except for sex (SMD = 0.334) and the location of the tear within the arthroscopy findings (SMD = 0.239) (*Appendix 2*). The nonsignificant Little's test (P = 0.283) suggests that PRWHE scores at 3 and 12 months were missing completely at random.

Table 3. Outcomes for the Patient Rated Wrist/Hand Evaluation (PRWHE) and Patient-Specific Function Score (PSFS).

	Early active mobilization group			**Longer immobilization group**			**3 months**		**12 months**	
	Intake EMMs (95% CI)	**3 months** EMMs (95% CI)	**12 months** EMMs (95% CI)	**Intake** EMMs (95% CI)	**3 months** EMMs (95% CI)	**12 months** EMMs (95% CI)	**Δ between group** EMMs (95% CI)	**Effect size** (95% CI)	**Δ between group** EMMs (95% CI)	**Effect size** (95% CI)
PRWHE										
N (Response rate)	*28 (100%)*	*27 (96%)*	*19 (68%)*	*76 (100%)*	*73 (96%)*	*57 (75%)*				
Total score	61.0 (54.11 - 68.0)	36.7 (29.7 – 43.8)	15.6 (7.57 – 23.7)	61.4 (57.2 - 65.6)	34.4 (30.2 – 38.6)	20.0 (15.4 – 24.7)	2.3 (-9.7 – 14.3)	-0.12 (-0.56 – 0.31)	-4.4 (-18.0 – 9.2)	0.21 (-0.23 – 0.64)
Pain score	32.2 (28.5 – 35.9)	19.2 (15.4 – 23.0)	10.0 (5.7 – 14.3)	32.6 (30.4 – 34.8)	18.7 (16.4 – 20.9)	12.0 (9.5 – 14.5)	0.5 (-5.9 – 7.0)	-0.05 (-0.49 – 0.38)	2.0 (-9.3 – 5.32)	0.17 (-0.26 – 0.61)
Function score	28.8 (25.1 – 32.6)	17.5 (13.7 – 21.3)	5.7 (1.3 – 10.1)	28.8 (26.5 – 31.1)	15.7 (13.4 – 18.0)	8.1 (5.5 – 10.6)	1.8 (-4.7 – 8.3)	-0.17 (-0.61 – 0.26)	-2.4 (-9.8 – 5.0)	-0.21 (-0.23 – 0.65)
PSFS										
N (Response rate)	*24 (86%)*	*24 (86%)*	*9 (32%)*	*27 (36%)*	*27 (36%)*	*23 (30%)*				
Average score	3.9 (3.0 – 4.8)	5.5 (4.6 – 6.4)	7.7 (6.6 – 8.9)	3.4 (2.5 – 4.2)	5.8 (4.9 – 6.6)	8.2 (7.2 – 9.1)	-0.3 (-2.1 – 1.6)	0.08 (-0.35 – 0.51)	-0.4 (-2.5 – 1.7)	0.12 (-0.32 – 0.55)

Significance levels for between group differences at 3 and 12 months were assessed using linear mixed models (Note: there were no significant differences between groups at 3 and 12 months). The response rate is calculated as the number of patients who provided data at the specific time point divided by the total number of patients in the subgroups (n=28 & n=76).

Abbreviations: EMMs – Estimated marginalized means; CI – Confidence level; * Significance level = <0.05

Patient-reported pain and hand function

Outcomes of the PRWHE total score, PRWHE pain score, PRWHE function score, and PSFS are presented in *Table 3*. No significant differences in PRWHE total score were found between both groups (*Figure 2*) at 3 months (effect size, -0.12; 95% CI, -0.56 – 0.31) and 12 months (effect size, 0.21; 95% CI, -0.23 – 0.64). The magnitude of the measured effect sizes (<0.35) and their confidence intervals indicate noninferiority on the PRWHE total score at 3 and 12 months after surgery. In addition, noninferiority was found in all outcomes of the PRWHE pain score, PRWHE function score, and PSFS.

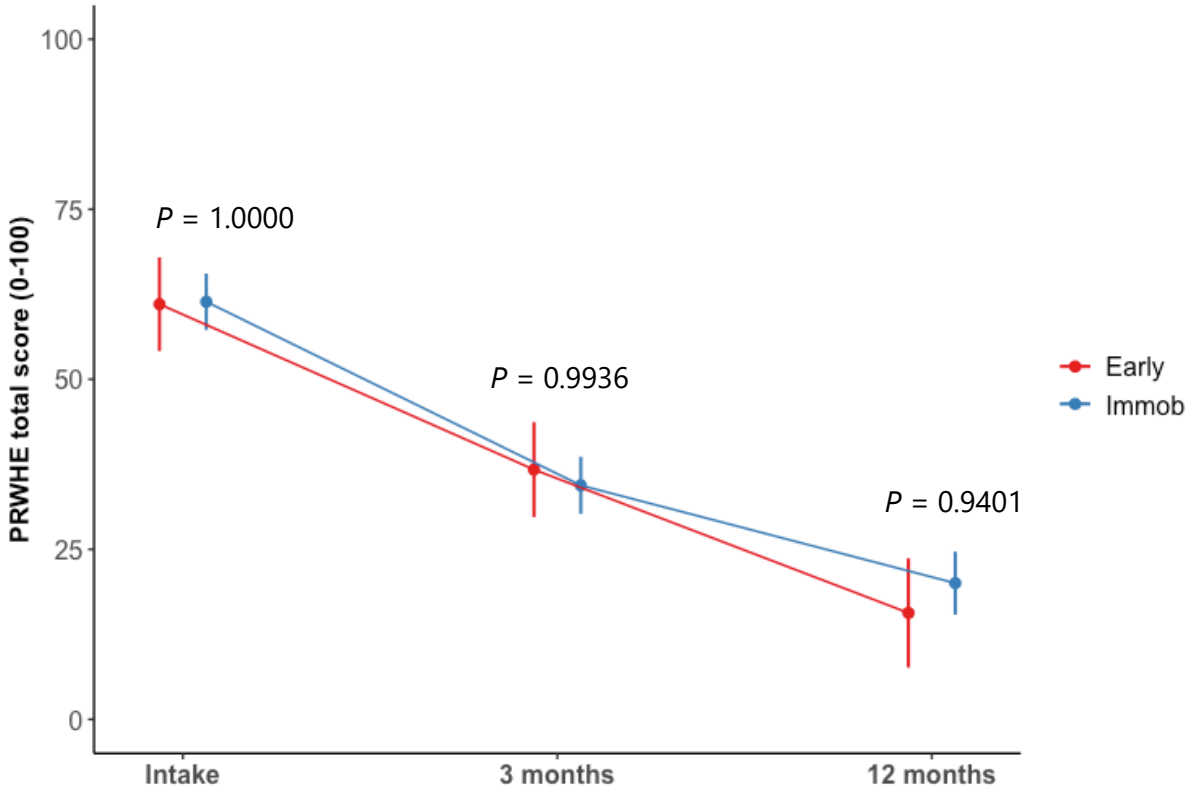

Figure 2. The mean patient-rated wrist/hand evaluation (PRWHE) total score at intake and 3 and 12 months after surgery, stratified by intervention group (red = early active mobilization group; blue = longer immobilization group). The error bars indicate the 95% confidence interval. The *P*-values indicate between-group significance.

AROM and grip strength

All AROM and grip strength effect sizes and their confidence intervals indicated noninferiority; *Table 4* presents the AROM and grip strength at each time point.

Table 4. Outcomes for the active range of motion (AROM) and gript strength.

	Early active mobilization group			**Longer immobilization group**			**3 months**		**12 months**	
	Intake EMMs (95% CI)	**3 months** EMMs (95% CI)	**12 months** EMMs (95% CI)	**Intake** EMMs (95% CI)	**3 months** EMMs (95% CI)	**12 months** EMMs (95% CI)	**Δ between group** EMMs (95% CI)	**Effect size** (95% CI)	**Δ between group** EMMs (95% CI)	**Effect size** (95% CI)
AROM										
N (Response rate)	*23 (82%)*	*21 (75%)*	*7 (25%)*	*73 (96%)*	*61 (80%)*	*29 (38%)*				
Dorsal flexion *(°)*	-66.0 (-70.9 – -61.0)	-61.9 (-67.0 – -56.8)	-69.4 (-76.8 – -61.9)	-64.4 (-67.1 – -61.6)	-62.6 (-65.5 – -59.6)	-71.5 (-75.3 – -67.7)	-0.6 (-8.0 – 9.28)	-0.05 (-0.49 – 0.38)	2.2 (-10.1 – 14.4)	-0.11 (-0.55 – 0.32)
Palmar flexion *(°)*	63.2 (57.0 – 69.3)	58.0 (51.6 – 64.4)	68.7 (64.6 – 74.3)	61.4 (58.0 – 64.9)	58.4 (54.6 – 62.1)	69.5 (64.6 – 74.3)	-0.2 (-11.2 – 10.4)	0.02 (-0.41 – 0.46)	-0.7 (-16.5 – 15.0)	0.03 (-0.40 – 0.48)
Supination *(°)*	-78.7 (-84.7 – -72.7)	-66.2 (-72.4 – -60.1)	-76.2 (-85.7 – -66.6)	-75.6 (-78.9 – -72.3)	-66.6 (-70.3 – -63.0)	-78.2 (-83.0 – -73.5)	0.4 (-10.0 – 10.0)	-0.02 (-0.46 – 0.41)	2.1 (-13.5 – 17.7)	-0.09 (-0.52 – 0.35)
Pronation *(°)*	81.8 (76.9 – 86.8)	70.1 (65.2 – 75.0)	76.7 (68.5 – 85.0)	76.9 (74.3 – 79.6)	71.2 (68.3 – 74.2)	78.2 (74.1 – 82.3)	-1.2 (-9.5 – 7.2)	0.08 (-0.35 – 0.52)	-1.5 (-14.9 – 11.9)	0.07 (-0.36 – 0.51)
Radial deviation *(°)*	-21.1 (-24.5 – -17.8)	-12.6 (-16.0 – -9.1)	-17.1 (-22.6 – -11.5)	-18.8 (-20.6 – -17.0)	-16.5 (-18.6 – -14.5)	-19.0 (-21.7 – -16.2)	4.0 (-1.9 – 9.8)	-0.43 (-0.87 – 0.01)	1.9 (-7.1 – 11.0)	-0.14 (-0.57 – 0.29)
Ulnar deviation *(°)*	28.3 (24.4 – 32.2)	27.4 (23.3 – 31.5)	29.8 (23.2 – 36.4)	27.8 (25.7 – 29.9)	26.2 (23.8 – 28.6)	28.5 (25.3 – 31.8)	1.2 (-5.7 – 8.1)	-0.11 (-0.55 – 0.32)	1.3 (-9.4 – 12.0)	-0.08 (-0.51 – 0.35)
Grip strength										
N (Response rate)	21 (75%)	21 (75%)	7 (25%)	65 (86%)	55 (72%)	29 (38%)				
Affected side *(kg)*	24.2 (19.1 – 29.3)	21.8 (16.7 – 26.9)	30.3 (23.9 – 36.8)	24.7 (21.8 – 27.6)	25.4 (22.4 – 28.3)	32.2 (28.8 – 35.7)	-3.6 (-12.3 – 5.1)	0.27 (-0.17 – 0.70)	-1.9 (-12.6 – 8.7)	0.12 (-0.32 – 0.55)

Significance levels for between group differences at 3 and 12 months were assessed using linear mixed models (Note: there were no significant differences between groups at 3 and 12 months). The response rate is calculated as the number of patients who provided data at the specific time point divided by the total number of patients in the subgroups (n=28 & n=76).

Abbreviations: EMMs – Estimated marginalized means; CI – Confidence level; * Significance level = <0.05

Return to work

The median time until RTW among patients who had paid labor before surgery was 10 weeks (95% CI, 4 – *NA*) in the early active mobilization group and 7 weeks (95% CI, 4 -12) in the longer immobilization group (*Figure 3*). After a year, the early active mobilization group had a cumulative RTW of 73% (95% CI, 42% - 88%), while the longer immobilization group had a cumulative RTW of 93% (81% - 98%; *Appendix 3*). No significant differences were found between both groups (*P* = 0.2).

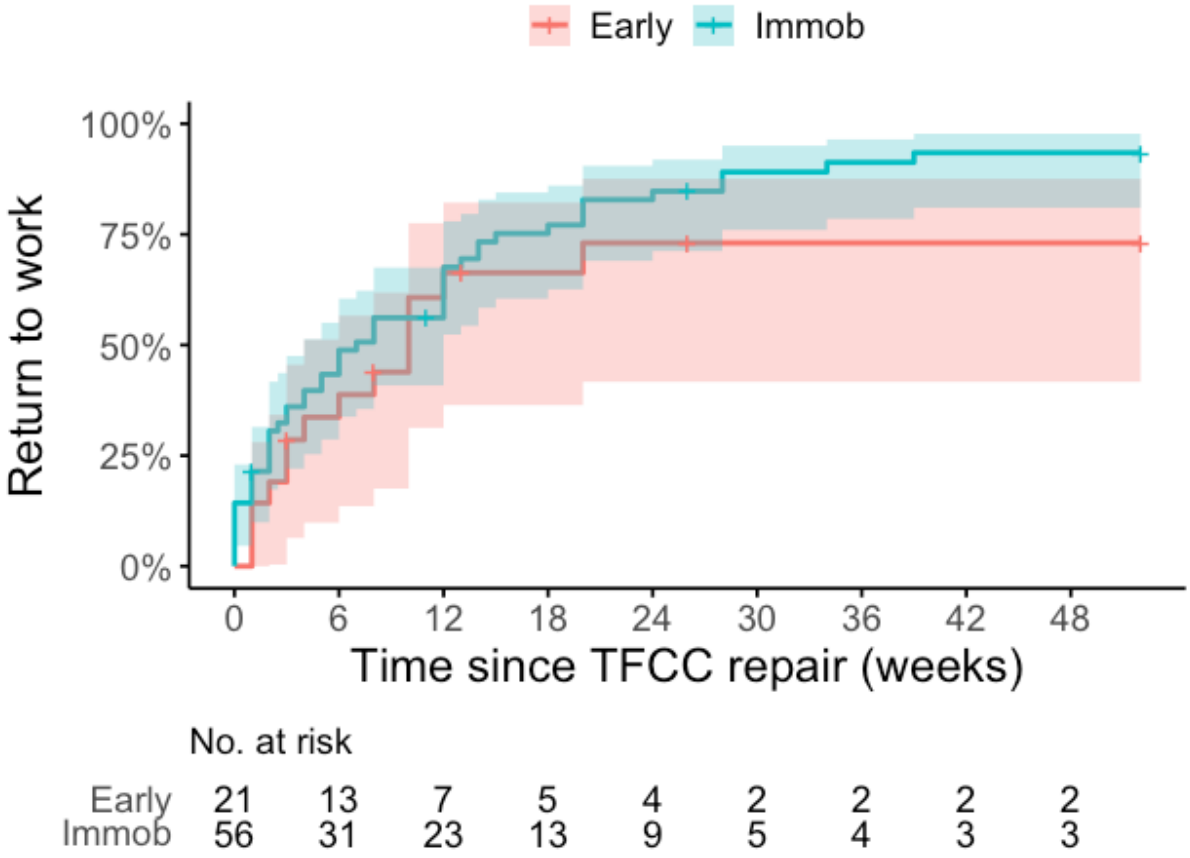

Figure 3. Kaplan-Meier curve for return to work after open TFCC repair in weeks, with 95% confidence intervals stratified by intervention group (red = early active mobilization group; green = longer immobilization group). Patients at risk (no. at risk) are those who had paid labor prior to surgery but did not return to work.

Complications

Complications and adverse protocol deviations occurred in 36% (10/28) of patients in the early active mobilization group, compared to 38% (29/76) in the longer immobilization group. There was no significant difference in the occurrence between groups (*P* = 0.627; *Table 5*).

Table 5. Complications in the early active mobilization group and the longer immobilization group, scored according to the ICHOM Complications in Hand and Wrist conditions (ICHAW) classification, modified and derived from Clavien-Dindo (2009)

Complications; Treatment	Early active mobilization group (n = 28)	Longer immobilization group (n = 76)	*P*-value
Overall	10 (36%)	29 (38%)	0.627
Grade I*	4 (14%)	14 (18%)	
ECU tendinitis; splinting	1	1	
Adhesions/scar tenderness; hand therapy	2	1	
Irritation suture; conservative	1	1	
De Quervain's disease; hand therapy	0	2	
Persisting ulnar pain; hand therapy	0	2	
Stiffness; hand therapy	0	5	
Skin defect through cast; conservative	0	1	
Postoperative pain; additional analgesics	0	1	
Grade II†	5 (18%)	9 (12%)	
De Quervain's disease; corticosteroid injection	1	1	
ECU tendinitis; corticosteroid injection	4	7	
Persisting ulnar pain; corticosteroid injection	0	1	
Grade III A‡	0 (0%)	0 (0%)	
Grade III B§	1 (4%)	6 (8%)	
Neuroma distal branch ulnaris; excision	1	0	
Re-rupture; indication for redo-repair	0	1	
De Quervain's disease; Quervain release	0	1	
Persisting ulnar pain; scopic Wafer procedure	0	1	
Persisting ulnar pain; extensor carpi ulnaris loop	0	1	
Persisting ulnar pain; ulnar shortening	0	2	
Grade III C¶	0 (0%)	0 (0%)	

*Any deviation from the normal treatment course without the need for surgical, endoscopic, and radiologic interventions. Acceptable therapeutic regimens are extra analgesics and additional hand therapy/ splinting/cast. This grade includes, for example, tendinitis, scar tenderness, temporary sensory disturbances, and so forth.

†Any deviation from the normal treatment course requiring antibiotics, steroid injections, or other pharmacologic treatment not listed in grade I. Also included are wound infections and hematoma's not needing anesthesia.

‡Any deviation from the normal treatment course requiring minor surgical intervention under local anesthesia (e.g., irritating K-wire, suture removal subcutaneously). Also, this includes tendinitis, scar tenderness, persistent pain, and so forth not responding to conservative therapy, drugs, or injections.

§Major surgical intervention under regional or general anesthesia (e.g., repeat surgery, tenolysis, neurolysis, nerve repair or surgery for tendon rupture, breaking of the plate, nonunion, initial prosthesis failure).

¶Complex regional pain syndrome, diagnosed using Budapest criteria, independent of the initiated treatment.

DISCUSSION

This study investigated whether an early active wrist rotation protocol after open TFCC repair is non-inferior to long-term wrist immobilization 3 months after surgery in terms of pain and hand function. We found that pain and hand function at 3 months were non-inferior between groups using the PRWHE and PSFS. Additionally, similar between-group results were found for the secondary outcomes of pain and hand function at 12 months, AROM, grip strength, RTW, and complications. Suggesting an early active mobilization protocol is non-inferior and safe compared to a longer immobilization protocol.

To our knowledge, this is the first study focusing on rehabilitation, comparing two alternative rehabilitation methods following TFCC repair.[15] The non-inferior results of this study align with the similar outcomes observed in earlier research that compared early active mobilization to longer immobilization after a 3-ligament tenodesis procedure and a Weilby-sling procedure.[42,53] Additionally, results on the PRWHE of both groups in this study are consistent with previous studies on open and arthroscopic TFCC repair.[6,17–20,54] Furthermore, comparing complications between studies is difficult due to variations in reporting methods. Our study used the ICHAW tool, which is transparent and includes milder complications that may have been overlooked in previous studies, yielding higher complication rates.[41,55,56] However, the occurrence of complications in our study aligns with previous research that reported complications adequately.[16,57,58] This consistency in findings suggests that early active mobilization can be a comparable and potentially effective alternative to prolonged immobilization.

Despite similar findings, early active mobilization might benefit the patient by being safe and resulting in comparable functional outcomes. As demonstrated by the comparison of above and below elbow immobilization following TFCC repair, early active mobilization may result in fewer limitations in daily living during the early stage of recovery and higher convenience throughout recovery.[17] To investigate this hypothesis, future research should include outcomes on differences in limitations and convenience throughout this early recovery phase. Furthermore, while no significant differences in the median time to RTW were found, it is worth mentioning that the initial time to RTW in both groups was shorter than the previously reported 12-week period in research on the RTW after TFCC repair.[39]

As mentioned earlier, our study found that starting rotation exercises early after TFCC repair is safe and does not worsen outcomes. However, the initiation of certain degrees of movement was fixed to a rigid timeframe. Adopting a progressive rehabilitation program, similar to post-ACL surgery rehabilitation[15,22], could potentially yield more significant differences in outcomes. This entails transitioning from strict time-framed protocols to a progression-based program that gradually increases the difficulty. It is crucial to responsibly consider the forces applied to healing ligaments, tissue healing, potential concomitant surgery, and individual patient goals.[22] However, it is important to interpret this hypothesis

with caution, as the safety and effectiveness of this approach in rehabilitation after TFCC repair remain uncertain. Further research is needed to establish its safety and efficacy.

Our study has a few strengths and limitations. First, a notable limitation of this study is that we could not meet the estimated sample size for the early active mobilization group due to time constraints, leading to reduced statistical power. To mitigate this concern, we matched within the PSM on a one-to-three basis. However, due to the limited sample size for the early active mobilization group, the results of this study should be interpreted with caution as the statistical power may be insufficient to detect significant differences.

Second, the observational nature of this study may be a limitation since the treatment patients received was not fully standardized; to control for this, we manually reviewed all medical records of patients who were potentially eligible for inclusion. However, we could not check whether patients adhered to the protocol at home or wore their splints according to the prescribed schedule. As a result, the potential variation in hand usage and exercise due to differing levels of adherence may introduce adherence bias. Nevertheless, the observational design of this study is also a strength because the data collected during routine care accurately reflects real-world daily care. By stratifying patients based on treatment period and adjusting for relevant covariates within the PSM, as identified in the literature as predictors of PRWHE score and time until RTW after open TFCC repair, we aimed to mitigate confounding by indication and enhance the reliability of our findings.[39,49] Unfortunately, due to our study's small sample size, we could not obtain a sufficient between-group balance with SMDs below 0.2 for baseline characteristics, type of work, and the location of the tear. However, according to the literature, the location of the tear was not found to be a prognostic factor impacting PRWHE scores and RTW after surgery. While the type of work was only identified as a prognostic factor influencing the time until RTW.[39,49] As a result, an imbalance was observed between the groups, with the early active mobilization group having more moderate work and the longer immobilization group having more light work participants. This imbalance potentially contributed to the observed but not statistically significant difference in median time before RTW, favoring the longer immobilization group.

Lastly, another limitation of this study is missing data. However, we observed no systematic differences between responders and non-responders except for SMDs just above 0.2 for the covariates sex and location of the tear. In addition, the nonsignificant Little's test further suggests that data were missing completely at random.

CONCLUSION

In conclusion, the findings of this study suggest that an early active mobilization protocol is non-inferior to longer immobilization in terms of pain and hand function, and it does not lead to more complications. A future randomized clinical trial using an adequate sample size is required to confirm these findings.

REFERENCES

1. **Kleinman WB**. Stability of the Distal Radioulna Joint: Biomechanics, Pathophysiology, Physical Diagnosis, and Restoration of Function What We Have Learned in 25 Years. *J Hand Surg Am* 2007;32(7):1086–1106.

2. **Skalski MR, White EA, Patel DB, Schein AJ, RiveraMelo H, Matcuk GR**. The Traumatized TFCC: An Illustrated Review of the Anatomy and Injury Patterns of the Triangular Fibrocartilage Complex. *Curr Probl Diagn Radiol* Elsevier, 2016;45(1):39–50.

3. **Brogan DM, Berger RA, Kakar S**. Ulnar-sided wrist pain: A critical analysis review. *J Wrist Surg* 2019;7(5).

4. **Palmer AK**. Triangular fibrocartilage complex lesions: A classification. *J Hand Surg Am* 1989;14(4):594–606.

5. **Atzei A, Luchetti R, Braidotti F**. Arthroscopic foveal repair of the triangular fibrocartilage complex. *J Wrist Surg* 2015;4(1):22–30.

6. **Feitz R, Oest MJW van der, Heijden EPA van der, Slijper HP, Selles RW, Hovius SER**. Patient-reported outcomes and function after reinsertion of the triangular fibrocartilage complex by open surgery. *Bone Joint J* 2021;103-B(4):711–717.

7. **Fok MWM, Fang CX, Lau TW, Fung YKE, Fung BKK, Leung FKL**. The status of triangular fibrocartilage complex after the union of distal radius fractures with internal plate fixation. *Int Orthop* 2018;42(8):1917–1922.

8. **Abe Y, Fujii K, Fujisawa T**. Midterm Results after Open versus Arthroscopic Transosseous Repair for Foveal Tears of the Triangular Fibrocartilage Complex. *J Wrist Surg* 2018;7(4):292–297.

9. **Srinivasan RC, Shrouder-Henry JJ, Richard MJ, Ruch DS**. Open and Arthroscopic Triangular Fibrocartilage Complex (TFCC) Repair. *J Am Acad Orthop Surg* 2021;29(12):518–525.

10. **Park MJ, Jagadish A, Yao J**. The rate of triangular fibrocartilage injuries requiring surgical intervention. *Orthopedics* 2010;33(11):806.

11. **Iwasaki N, Nishida K, Motomiya M, Funakoshi T, Minami A**. Arthroscopic-assisted repair of avulsed triangular fibrocartilage complex to the fovea of the ulnar head: a 2- to 4-year follow-up study. *Arthroscopy* [Internet] United States, 2011;27(10):1371–8.

12. **Bayoumy MA, Elkady HA, Said HG, El-Sayed A, Saleh WR**. Short-term evaluation of arthroscopic outside-in repair of ulnar side TFCC tear with vertical mattress suture. *J Orthop* [Internet] M.A. Bayoumy, Orthopaedic and Traumatology Department, Assiut University Hospital, Assiut, Egypt, 2016;13(4):455–460.

13. **Garcia-Elias M, Smith DE, Llusá M**. Surgical approach to the triangular fibrocartilage complex. *Tech Hand Up Extrem Surg* 2003;7(4):134–140.

14. **Atzei A, Rizzo A, Luchetti R, Fairplay T**. Arthroscopic foveal repair of triangular

fibrocartilage complex peripheral lesion with distal radioulnar joint instability. *Tech Hand Up Extrem Surg* 2008;12(4):226–35.

15. **McCarron L, Bindra R, Coombes BK, Bisset L**. Wrist and forearm range of motion commencement time following primary triangular fibrocartilage complex foveal repair surgery: A scoping review. *J Hand Ther* 2023;36(1):179–195.

16. **Andersson JK, Åhlén M, Andernord D**. Open versus arthroscopic repair of the triangular fibrocartilage complex: a systematic review. *J Exp Orthop* Journal of Experimental Orthopaedics, 2018;5(1):1–10.

17. **Jung H-S, Park J-G, Park H-J, Lee JS**. Postoperative immobilization using a short-arm cast in the semisupination position is appropriate after arthroscopic triangular fibrocartilage complex foveal repair. *Bone Joint J* 2022;104-B(2):249–256.

18. **Auzias P, Camus EJ, Moungondo F, Overstraeten L Van**. Arthroscopic-assisted 6U approach for foveal reattachment of triangular fibrocartilage complex with an anchor: Clinical and radiographic outcomes at 4 years' mean follow-up. *Hand Surg Rehabil* 2020;39(3):193–200.

19. **Kermarrec G, Cohen G, Upex P, Fontes D**. Arthroscopic Foveal Reattachment of the Triangular Fibro Cartilaginous Complex. *J Wrist Surg* 2020;9(3):256–262.

20. **Jung HS, Song K-S, Jung HS, Yoon BI, Lee J-S, Park MJ**. Clinical Outcomes and Factors Influencing These Outcome Measures Resulting in Success After Arthroscopic Transosseous Triangular Fibrocartilage Complex Foveal Repair. *Arthrosc - J Arthrosc Relat Surg* 2019;35(8):2322–2330.

21. **Hauser RA, Dolan EE, Phillips HJ, Newlin AC, Moore RE, Woldin BA**. Ligament Injury and Healing: A Review of Current Clinical Diagnostics and Therapeutics. *Open Rehabil J* 2013;6(1):1–20.

22. **Cavanaugh JT, Powers M**. ACL Rehabilitation Progression: Where Are We Now? *Curr Rev Musculoskelet Med* 2017;10(3):289–296.

23. **Haugstvedt JR, Søreide E**. Arthroscopic Management of Triangular Fibrocartilage Complex Peripheral Injury. *Hand Clin* 2017;33(4):607–618.

24. **Thiru RG, Ferlic DC, Clayton ML, McClure DC**. Arterial anatomy of the triangular fibrocartilage of the wrist and its surgical significance. *J Hand Surg Am* 1986;11(2):258–263.

25. **Elm E von, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al.** The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol* 2008;61(4):344–9.

26. **Tang JB, Giddins G**. Why and how to report surgeons' levels of expertise. *J Hand Surg (European Vol* 2016;41(4):365–366.

27. **Erasmus MC, Equipe Zorgbedrijven**. GemsTracker. https://gemstracker.org , (date

last accessed 27 September 2022).

28. **Selles RW, Wouters RM, Poelstra R, Oest MJW Van Der, Porsius JT, Hovius SER, et al.** Routine Health Outcome Measurement: Development, Design, and Implementation of the Hand and Wrist Cohort. *Plast Reconstr Surg* 2020;146(2):343–354.

29. **Feitz R, Kooij YE van, Stege MHP ter, Oest MJW van der, Souer JS, Wouters RM, et al.** Closing the loop: a 10-year experience with routine outcome measurements to improve treatment in hand surgery. *EFORT Open Rev* 2021;6(6):439–450.

30. **Ruch DS, Yang CC, Smith BP**. Results of acute arthroscopically repaired triangular fibrocartilage complex injuries associated with intra-articular distal radius fractures. *Arthrosc - J Arthrosc Relat Surg* 2003;19(5):511–516.

31. **Kim JK, Kook SH, Kim YK**. Comparison of Forearm Rotation Allowed by Different Types of Upper Extremity Immobilization. *J Bone Jt Surg* 2012;94(5):455–460.

32. **Videler AJ, Schreuders TAR**. Nederlandse versie van de patient rated wrist/ hand evaluation. *Ned Tijdschr Handtherapie* 2008;17(2):8–11.

33. **MacDermid JC, Turgeon T, Richards RS, Beadle M, Roth JH**. Patient Rating of Wrist Pain and Disability: A Reliable and Valid Measurement Tool. *J Orthop Trauma* 1998;12(8):577–586.

34. **Kooij YE van, Poelstra R, Porsius JT, Slijper HP, Warwick D, Selles RW**. Content validity and responsiveness of the Patient-Specific Functional Scale in patients with Dupuytren's disease. *J Hand Ther* 2021;34(3):446–452.

35. **Abbott JH, Schmitt JS**. The Patient-Specific Functional Scale was valid for group-level change comparisons and between-group discrimination. *J Clin Epidemiol* 2014;67(6):681–688.

36. **ICHOM**. ICHOM - Standard sets hand and wrist conditions. https://connect.ichom.org/standard-sets/hand-and-wrist-conditions/ , (date last accessed 14 February 2023).

37. **Mathiowetz V, Weber K, Volland G, Kashman N**. Reliability and validity of grip and pinch strength evaluations. *J Hand Surg Am* 1984;9(2):222–6.

38. **Teunissen JS, Feitz R, Shaer S Al, Hovius S, Selles RW, Heijden B Van der**. Return to Usual Work Following an Ulnar Shortening Osteotomy: A Sample of 111 Patients. *J Hand Surg Am* 2021;

39. **Feitz R, Teunissen JS, Oest MJW van der, Heijden EPA van der, Selles RW, Hovius SER**. Factors associated with return to work after open reinsertion of the triangular fibrocartilage. *Hand Surg Rehabil* 2021;40(4):405–412.

40. **Wouters RM, Jobi-Odeneye AO, la Torre A de, Joseph A, ICHOM Hand and Wrist Working Group, Hovius SER**. A Standard Set for Outcome Measurement in Patients With Hand and Wrist Conditions: Consensus by the International Consortium for Health Outcomes Measurement Hand and Wrist Working Group. *J Hand Surg Am*

2021;46(10):841-855.e7.

41. **Hoogendam L, Oest MJW van der, Vermeulen GM, Feitz R, Hovius SER, Zuidam JM, et al.** Prevalence of Complications and Association With Patient-Reported Outcomes After Trapeziectomy With a Weilby Sling: A Cohort Study. *J Hand Surg Am* 2023;48(5):469–478.

42. **Tsehaie J, Wouters RM, Feitz R, Slijper HP, Hovius SER, Selles RW**. Shorter vs Longer Immobilization After Surgery for Thumb Carpometacarpal Osteoarthritis: A Propensity Score-Matched Study. *Arch Phys Med Rehabil* 2019;100(11):2022-2031.e1.

43. **Hahn S**. Understanding noninferiority trials. *Korean J Pediatr* 2012;55(11):403–407.

44. **Cohen J**. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Routledge, 1988.

45. **Rubin DB**. The design versus the analysis of observational studies for causal effects: parallels with the design of randomized trials. *Stat Med* 2007;26(1):20–36.

46. **Rosenbaum PR, Rubin DB**. The central role of the propensity score in observational studies for causal effects. *Matched Sampl Causal Eff* 2006;(1083):170–184.

47. **Freemantle N, Marston L, Walters K, Wood J, Reynolds MR, Petersen I**. Making inferences on treatment effects from real world data: Propensity scores, confounding by indication, and other perils for the unwary in observational research. *BMJ* 2013;347:1–5.

48. **Austin PC**. An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behav Res* 2011;46(3):399–424.

49. **Feitz R, Stip D, Oest M van der, Souer S, Hovius S, Selles R**. Prognostic Factors in Open Triangular Fibrocartilage Complex (TFCC) Repair. *J Hand Surg Glob Online* 2021;3(4):176–181.

50. **Gruber FA**. Tutorial: survival analysis--a statistic for clinical, efficacy, and theoretical applications. *J Speech, Lang Hear Res* 1999;42(2):432–447.

51. **Peters SAE, Bots ML, Ruijter HM Den, Palmer MK, Grobbee DE, Crouse JR, et al.** Multiple imputation of missing repeated outcome measurements did not add to linear mixed-effects models. *J Clin Epidemiol* 2012;65(6):686–695.

52. **Little RJA**. A Test of Missing Completely at Random for Multivariate Data with Missing Values. *J Am Stat Assoc* 1988;83(404):1198–1202.

53. **Bakker D, Colaris JW, Kraan GA, Mathijssen N, Selles R, Smit X, et al.** Is Early Active Motion After 3-Ligament Tenodesis Noninferior to Late Active Motion? A Prospective, Multicenter Cohort Study. *J Hand Surg Am* 2022;47(11):1076–1084.

54. **Bayoumy MA, El-Sayed A, Elkady HA, Saleh WR, Said HG, Ali AM**. Arthroscopic Treatment of Type 1B Triangular Fibrocartilage Complex Tear by "Outside-In" Repair Technique Using Transcapsular Transverse Mattress Suture. *Arthrosc Tech*

2017;6(5):e1581–e1586.

55. **Koopman JE, Zweedijk BE, Hundepool CA, Duraku LS, Smit J, Wouters RM, et al.** Prevalence and Risk Factors for Postoperative Complications Following Open A1 Pulley Release for a Trigger Finger or Thumb. *J Hand Surg Am* 2022;47(9):823–833.

56. **Teunissen JS, Wouters RM, Shaer S Al, Zöphel OT, Vermeulen GM, Hovius SER, et al.** Outcomes of ulna shortening osteotomy: a cohort analysis of 106 patients. *J Orthop Traumatol* 2022;23(1):1.

57. **Anderson ML, Larson AN, Moran SL, Cooney WP, Amrami KK, Berger RA**. Clinical Comparison of Arthroscopic Versus Open Repair of Triangular Fibrocartilage Complex Tears. *J Hand Surg Am* 2008;33(5):675–682.

58. **Luchetti R, Atzei A, Cozzolino R, Fairplay T, Badur N**. Comparison between open and arthroscopic-assisted foveal triangular fibrocartilage complex repair for post-traumatic distal radio-ulnar joint instability. *J Hand Surg Eur Vol* 2014;39(8):845–55.

APPENDIX

Appendix 1. Return-to-work questionnaire

Question	Answer
Are you back at work?	(1) Yes (2) No, because of the hand/wrist problem I am currently being treated for (3) No, because of something else
If the patient answers "yes," the following 5 questions will be asked:	
(1) How many hours per week do you usually work?	
(2) How many hours per week are you currently working?	
(3) How many weeks after your initial surgery did you return to your work?	
(4) Are you currently doing your regular work or are (temporary) adjustments made to your work?	
(5) How many weeks after starting your initial surgery did you return to your original work?	

Appendix 2. Characteristics and Patient Rated Wrist/Hand Evaluation (PRWHE) scores at intake between responders (patients who completed the PRWHE after 3 and months) and non-responders (patients who did not).

	Responders	**Non-responders**	**SMD**
n	65	130	
Age, years (mean (SD))	41.55 (13.46)	40.53 (13.54)	0.076
Sex, male (%)	26 (40.0)	32 (24.6)	0.334
Duration of symptoms, months (median (IQR))	8.00 [4.00, 12.00]	9.00 [5.00, 13.75]	0.187
Type of work n (%)			0.123
Not working (including retired/unable to work)	8 (12.3)	19 (14.6)	
Light physical work	26 (40.0)	55 (42.3)	
Moderate physical work	22 (33.8)	37 (28.5)	
Heavy physical work	9 (13.8)	19 (14.6)	
Dominant side not treated, n (%)	23 (35.4)	49 (37.7)	0.048
PRWHE total score at intake (mean (SD))	60.26 (18.04)	60.90 (16.50)	0.037
PRWHE pain score at intake (mean (SD))	32.25 (9.12)	33.35 (8.16)	0.128
PRWHE function score at intake (mean (SD))	28.02 (10.63)	27.55 (10.43)	0.045
Arthroscopy findings, n (%*)			0.239
Central tear	3 (8.1)	7 (8.2)	
Lateral tear or foveal detachment	29 (78.4)	59 (69.4)	
Distal avulsion	1 (2.7)	3 (3.5)	
Radial tear	4 (10.8)	16 (18.8)	

SMD – standardized mean differences; SD – standard deviation; IQR - interquartile range; PRWHE – Patient Rated Wrist/Hand Evaluation; * – percentage of the arthroscopic findings

Appendix 3. Outcomes for the cumulative return to work.

	Early active mobilization group		**Longer immobilization group**	
	Number at risk†	Cumulative return to work	Number at risk†	Cumulative return to work
Intake	21	-	56	-
3 months	7	66% (36% - 82%)	23	68% (52% - 78%)
12 months	2	73% (42% - 88%)	3	93% (81% - 98%)

†Patients at risk (number at risk) are those who had paid labor prior to surgery but did not return to work.