Hand Surgery and Rehabilitation xxx (2020) xxx–xxx

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Original article

Does earlier splint removal truly affect functional recovery and kinesiophobia after tendon repair?

L'ablation précoce des attelles affecte-t-elle vraiment le rétablissement fonctionnel et le niveau de kinésiophobie après les réparations tendineuses ?

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ARTICLE INFO

Article history:
Received 18 November 2019
Received in revised form 7 January 2020
Accepted 19 January 2020
Available online xxx

Keywords:
Tendon repair
Hand therapy
Hand surgery
Kinesiophobia
Splinting Traduction en Français.

ABSTRACT

Splinting how the hand can be used in daily life. Therefore, earlier splint removal is thought to improve functional recovery. The aim of our study was to assess the outcomes of patients who removed their splint and started using their hand earlier and compare them to patients who received routine care. Patients with tendon repairs were divided into two groups: Group 1 (Early) started daily use of their hand at the 5th postoperative week and Group 2 (Later) at the 6th week. Patients received regular therapy consisting of an early motion protocol. Assessments were performed at three consecutive time points. Grip and pinch strength was measured and Nine-Hole Peg Test (9HPT) was performed. Disabilities of the Arm, Shoulder and Hand (DASH) and Tampa Scale for Kinesiophobia (TSK) were filled out. Both within-group and between-group analyses were performed. A total of 58 patients with flexor or extensor tendon repairs were analyzed. All parameters improved significantly over time within both groups ($P < 0.05$). When the time effect was ignored, kinesiophobia, disability and functional results – except grip strength – were statistically better in Group 2 group than in Group 1 ($P < 0.05$). Our results showed that, despite the clinically observed recovery, earlier splint removal and start of daily hand use did not truly improve the functional results. To us, this means that the remarkable advances in surgical techniques do not accelerate the physiological healing process. Therefore, clinical recommendations should always be supported with evidence-based data.
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Mots clés :
Réparation tendineuse
Kinésithérapie de la main
Chirurgie de la main
Kinésiophobie
Splinting

RÉSUMÉ

L'appareillage entraîne une restriction de l'utilisation de la main dans la vie quotidienne. Par conséquent, l'ablation précoce de l'attelle a été envisagée pour améliorer la récupération fonctionnelle. Le but de cette étude était d'évaluer les résultats des patients qui avaient enlevé l'attelle et avaient commencé à utiliser leur main plus tôt et à les comparer aux résultats des soins de routine. Les patients ayant subi une réparation tendineuse ont été divisés en 2 groupes: le groupe 1 (Précoce) a commencé l'utilisation quotidienne de la main à la 5e semaine et le groupe 2 (Tardif) à la 6e semaine. Les patients ont reçu la kinésithérapie régulière selon le protocole passif précoce. Les évaluations ont été effectuées à 3 moments consécutifs. La force de pince et de poigne a été mesurée et le Nine-Hole Peg Test (9HPT) a été exécuté. Le Disabilities of Arm, Shoulder and Hand (DASH) score et l'échelle de Tampa pour la kinésiophobie (TSK) ont été remplis. Des analyses intra-groupe et inter-groupe ont été effectuées. Au total, 58 patients présentant des réparations de tendon fléchisseur ou extenseur ont été analysés. Les résultats sur tous les paramètres s'amélioraient de façon significative au fil du temps au sein des deux groupes ($p < 0,05$).

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https://doi.org/10.1016/j.hansur.2020.01.006
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Please cite this article in press as: Tuna Z, et al. Does earlier splint removal truly affect functional recovery and kinesiophobia after tendon repair? Hand Surg Rehab (2020), https://doi.org/10.1016/j.hansur.2020.01.006

Lorsque le facteur temps était ignoré, la kinésiophobie, l'incapacité et les résultats fonctionnels – à l'exception de la force de poigne – étaient statistiquement meilleurs dans le groupe 2 que dans le groupe 1 ($p < 0,05$). Nos résultats montrent que, en dépit de la récupération clinique observée, l'ablation précoce de l'attelle et le début précoce de l'utilisation quotidienne de main n'ont pas vraiment amélioré les résultats fonctionnels. Il a été interprété que les progrès remarquables dans les techniques chirurgicales n'accélèrent pas le processus physiologique de guérison. Par conséquent, l'expérience clinique et l'encouragement au patient devraient toujours être étayés par des données basées sur la preuve.
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1. Introduction

Hand therapy protocols after tendon repair include varying types and duration of splint use. In our clinical practice, we use early passive motion protocols that requires dynamic immobilization for the first 6 weeks postoperatively [1]. During this immobilization period results, use of the injured hand is restricted which contributes to impairment in day-to-day activities [2]. Moreover, we have observed that patients experience clumsiness after splint removal, and that they avoid using their injured hand even though they are allowed to. We thought that this avoidance behavior may originate from the patient being worried about re-injury or tendon rupture. Based on this hypothesis, we assessed the kinesiophobia levels after tendon repair in a previous study [3]. Kinesiophobia is the fear of moving due to the risk of re-injury and/or pain [4]. In that study, we showed that a significant part of the patients with tendon repair have a fear of movement (kinesiophobia). Moreover, patients with lower kinesiophobia had better functional results than those with higher kinesiophobia [3].

Inspired by the results of our previous study, we planned this current study. We hypothesized that patients with tendon repairs avoid using their hand even after splint removal because of the restricted hand use within the splint. Parallel to our hypothesis, in some other studies, the immobilization period in the splint was shown to impair the patients' daily life and make them unhappy [5]. Moreover, another study reported that dynamic immobilization resulted in clumsiness and hesitation when using the affected hand [6].

Taking those findings into account, we thought that allowing the patient to use his hand earlier would help him to overcome the kinesiophobic thinking and use his hand better. Therefore, in this study, we hypothesized that patients would have better clinical results if they stopped using the splint earlier and were allowed to freely use their hand sooner. For this reason, the aim of this study was to assess the functional outcomes after tendon repairs in patients who removed the splint one week earlier and compare their results with those who received standard of care (removed the splint at the end of the 6th week).

2. Patients and methods

This study was carried out in a hand therapy clinic on the patients who underwent tendon repair and who were referred from the hand surgery department within the first postoperative week. The study protocol was approved by our local ethics committee.

2.1. Participants

Adult patients ($n = 68$) with primary flexor or extensor tendon repair who started to wear a dynamic splint within the first postoperative week were enrolled in the study. Patients with zones 2–3 flexor and zones 4–5 extensor tendon injuries were included while thumb tendon injuries were excluded. Patients with concomitant fracture, peripheral nerve (other than digital nerves) or vessel injury and patients with a history of systemic diseases (diabetes mellitus, rheumatoid arthritis, peripheral vascular disease etc.) were excluded. Patients who underwent tendon repair with grafting or two-step reconstruction were also excluded from the study. During the follow-up, some patients dropped out from the study or did not comply with the therapist's instructions. The data from these patients were also excluded from the analysis. Concomitant digital nerve injury was not considered as an exclusion criterion as it generally accompanies zone 2 tendon injuries with a small area of sensory deficit. Also, it was shown that concomitant digital nerve injury does not affect the clinical results after tendon injuries [7]. Therefore, patients with digital nerve injury were not excluded from the analysis.

2.2. Treatment

In our clinical practice, the surgical team directs patients for hand therapy within the first postoperative week. Patients with flexor or extensor tendon injuries are given a rubber-band dynamic mobilization splint to wear and they receive regular hand therapy sessions twice per week. Splint examples are given in Fig. 1. During a therapy session, pulsed ultrasound (1 watt/cm^2; 5 minutes) and massage are applied to the incision site. After application of those modalities, passive agonist and active antagonist exercises are performed on each operated finger. The exercises are repeated 10 times for each finger. The patient is instructed to perform exercises inside the dynamic splint with 10 repeats per waking

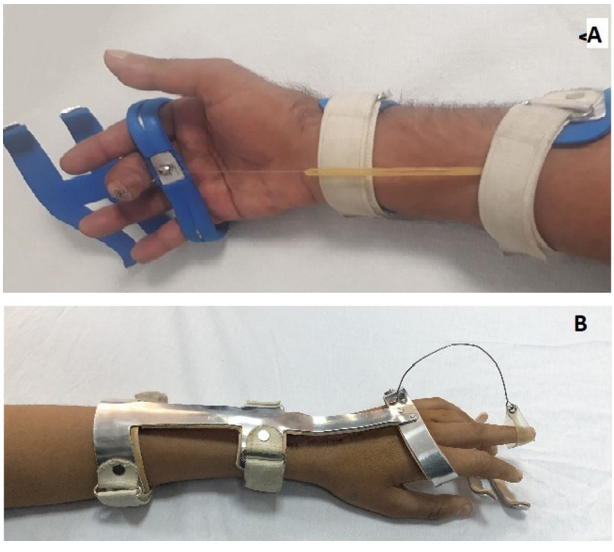

Fig. 1. Dynamic mobilization splints used in patients with flexor (A) and extensor (B) tendon repairs.

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hour when at home. For this study, we followed the same treatment schedule until the end of 5th week for all patients.

At the end of the 5th week, the patients were divided into two groups by simple randomization method (by tossing a coin to determine each patient's group). Group 1 (Early) consisted of the patients who removed the splint during the day and started active hand use in daily life at the end of the 5th week; while the patients in Group 2 (Later) group removed the splint and started daily use at the end of the 6th week. All the patients were evaluated three times in all: baseline, after 1 weeks use of the hand and after 3 weeks use of the hand. Thus, Group 1 was evaluated at the end of the 5th, 6th and 8th weeks, while Group 2 was evaluated at the end of the 6th, 7th and 9th weeks.

After the initial assessment, splint use during the day was reduced for both groups (during the 6th week for Group 1 and during the 7th week for Group 2). Patients could use their hand in light everyday activities (eating, dressing, hair washing, teeth brushing, using mobile phones, etc.) with no power grip. Splint use was continued for one more week during the night and when outdoors in both groups. After 1-week daily use of the hand, the second assessment was performed. Then, the splint was completely removed, and the patients were free to use their hand in daily life for 2 weeks. The final assessment was performed at the end of the 8th week for Group 1 (Early) group and at the end of 9th week for Group 2 (Later) group.

2.3. Exercise protocol

Patients in both groups performed passive agonist and active antagonist exercises with the help of the rubber band within the splint until the end of 5th week. After the first assessment, active tendon-gliding exercises were added to the treatment and ultrasound application was terminated. Massage was continued if needed. Thus, Group 1 started active exercises from the 5th week and Group 2 from the 6th week onward (Fig. 2). After the second evaluation, resistance exercises were started with rubber and putty. Thus, Group 1 started with resistance exercises at the 6th week and Group 2 at the 7th week. At each visit, patients were asked about the activities they performed in daily life and whether they had any complaints.

A flowchart summarizing the treatment protocol and assessment time points for both groups is given in Fig. 3.

2.4. Assessments

Functional assessments included grip strength and three different pinch strength (lateral, bipod and tripod) measurements and 9-Hole Peg Test (9HPT). Grip strength was measured with a hand-held dynamometer and pinch strength with a Pinch meter® (Fabrication Enterprises Incorporated, Irvington, NY). Measurements were performed in the standard position with the shoulder in full adduction, elbow in 90 degrees flexion and forearm in neutral position while the patient was sitting on a seat with back support. Each strength measurement was repeated three times and the average result was recorded for both hands in kilogram-force (kg-f) [8]. The two raters (AG and OM) were blinded to which group the patients belonged.

The 9HPT is a functional test of hand dexterity [9]. The test is scored as the number of seconds that subjects need to place nine pegs in a pegboard and then to remove them from the pegboard, using each hand. It is a valid, reliable and objective test used to evaluate hand function in a practical manner in various populations in the clinical setting [9].

Patients also filled out the Turkish version of the Disabilities of Arm, Shoulder and Hand (DASH) questionnaire and the Turkish version of the Tampa Scale for Kinesiophobia [10,11].

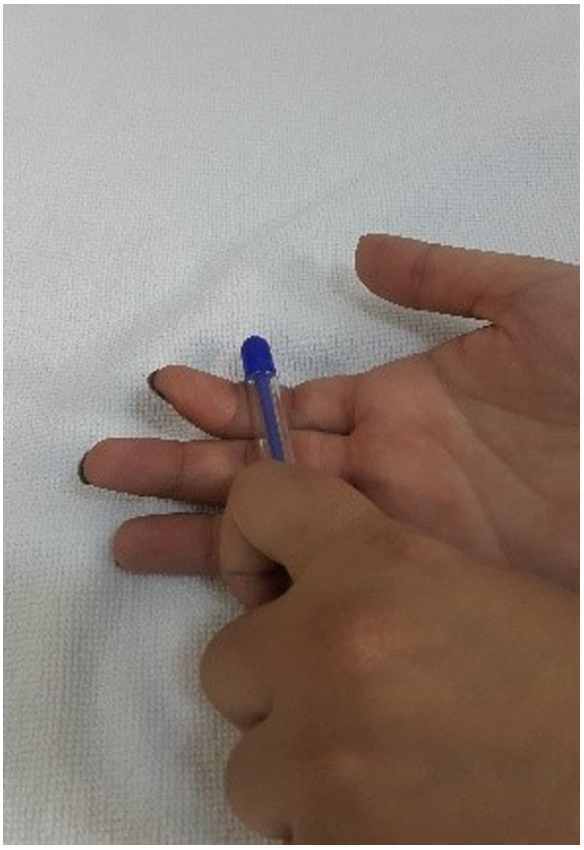

Fig. 2. An example of the blocking exercises that the patient was instructed to do at home.

2.4.1. Disabilities of Arm, Shoulder and Hand (DASH)

DASH is a self-reported questionnaire that was developed to evaluate the disability level of patients with any upper extremity problems. The first part of the questionnaire consists of 21 questions about physical function, 6 questions about pain, sensation, strength and mobility, 3 questions about social life. In the second part, there are 4 questions about work and 4 questions about playing an instrument and sports. A score of 0 to 100 is obtained and higher scores correspond to higher disability levels. The Turkish version of the questionnaire was found to be valid and reliable [10].

2.4.2. Tampa Scale for Kinesiophobia (TSK)

Kinesiophobia was evaluated using the Turkish version of the Tampa Scale for Kinesiophobia (TSK). This scale is comprised of 17 questions developed to measure fear of movement and/or re-injury. The scale includes injury/re-injury and fear-avoidance parameters during occupational activities. The scale uses 4-point Likert scoring (1 = entirely disagree, 4 = entirely agree). A total score is calculated after inverting items 4, 8, 12, and 16. The individual obtains a total score between 17 and 68. Higher scores correspond to higher kinesiophobia levels. The Turkish version of this scale has been reported to be valid [11].

2.5. Statistical analysis

Continuous variables are presented as mean ± standard deviation and categorical variables as counts and percentage. To test the differences between groups over time, general linear models with repeated measures were used. When a significant difference was revealed over time, multiple comparisons with Bonferroni

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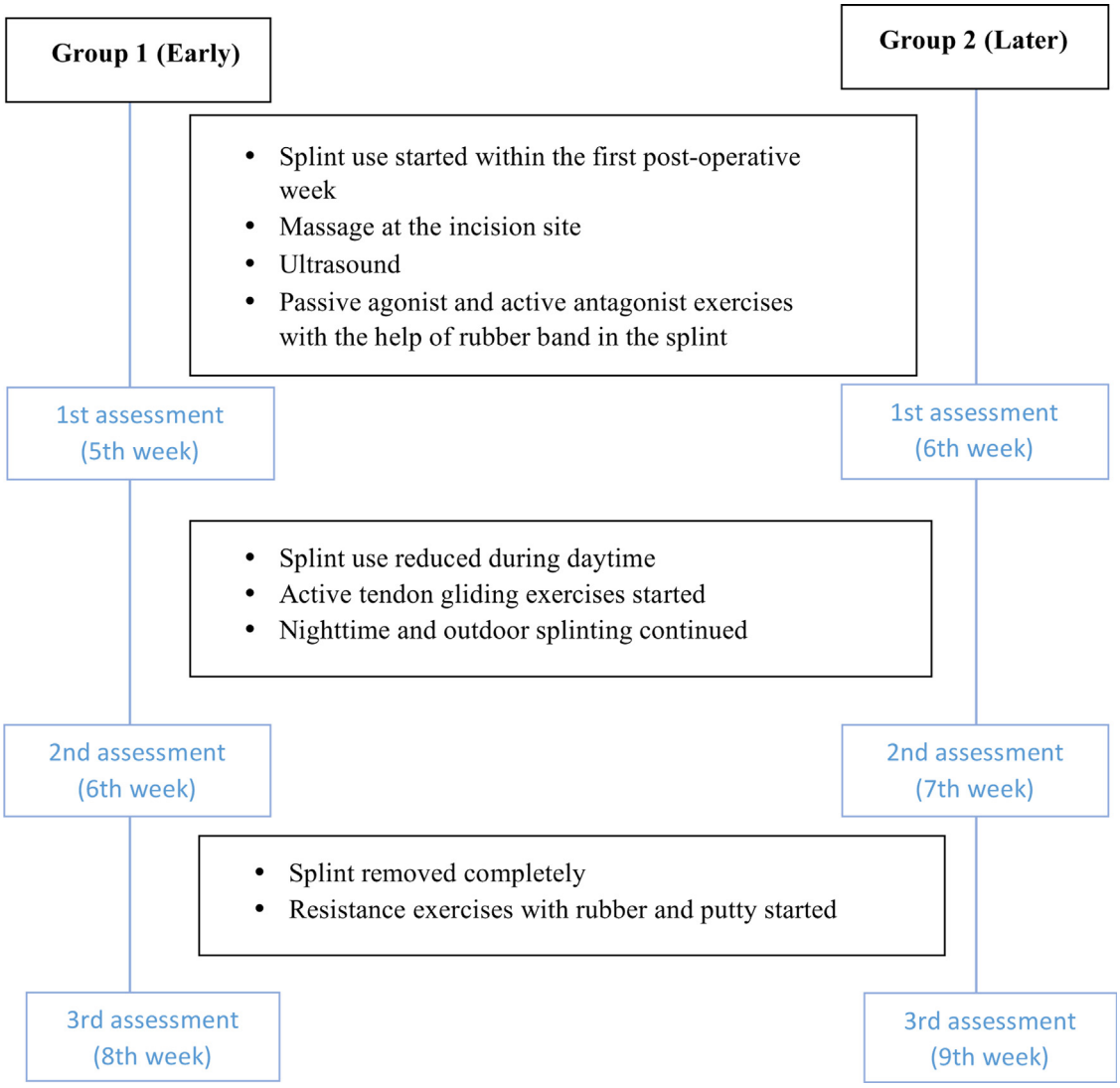

Fig. 3. Flowchart summarizing the treatment protocol and assessment time points for both groups.

adjustment were used as post-hoc tests. Statistical analyses were performed using SPSS version 14.01 and $P < 0.05$ was considered as indicative of a statistically significant difference.

3. Results

Sixty-eight patients were included in the study. Since two of the patients were living in another city and five discontinued the treatment in the first 5 weeks of the study, seven patients were excluded from the analysis. Additionally, three patients had a tendon rupture due a fall in the first 4 weeks postoperatively. Finally, Group 1 (Early) included 24 patients while Group 2 (Later) included 34 patients. Thus, the analysis was performed on a total of 58 patients.

The mean age was 31.6 ± 12.5 years for Group 1 and 34.3 ± 10.8 years for Group 2 ($P = 0.406$). There were 6 female and 18 male patients in Group 1 and 12 female and 22 male patients in Group 2.

Table 1 shows the results of the grip and pinch strengths and 9HPT performance for the affected hand. Grip and pinch strengths and 9HPT performance improved significantly over time as the results were better at each subsequent assessment ($P < 0.001$). The Time × Group interaction terms were not statistically significant ($P > 0.05$). This means that the change trend in all functional parameters by time within each group was similar ($P < 0.05$). When the time effect was ignored, Group 2 had better pinch strength and 9HPT results than Group 1 (Early) ($P < 0.05$).

The DASH and TSK scores for both groups are given in Table 2. There was a statistically significant time effect for both the DASH and TSK ($P < 0.05$). A significant decrease in each measurement was observed in the DASH scores ($P < 0.05$). For the TSK, the first and second results were similar, and the third score was significantly lower than the first two assessments ($P < 0.05$). The effect of the Time x Group interaction term on both scales were not statistically significant ($P > 0.05$). When the time effect was neglected, Group 2 (Later) had better results on both the DASH and TSK ($P < 0.001$ and $P = 0.024$, respectively).

4. Discussion

This study showed that, contrary to our hypothesis, starting daily use of the hand one week earlier does not truly improve

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Table 1
Comparison of the grip strength, lateral, bipod and tripod pinch strengths and 9HPT results in both groups at the three follow-up assessments.

		n	1st time	2nd time	3rd time	Time	Time × Group	Group
Grip strength	Group1	24	14.66 ± 10.37	19.13 ± 10.02	23.28 ± 11.25	< 0.001**	0.837	0.414
	Group2	34	11.94 ± 9.60	17.02 ± 11.79	21.29 ± 11.56			
	Overall	58	13.06 ± 9.93	17.9 ± 11.05	22.11 ± 11.38			
Lateral pinch	Group 1	23	6.91 ± 2.76	8.08 ± 2.97	9.28 ± 2.08	< 0.001**	0.564	0.006*
	Group 2	34	5.17 ± 2.69	6.05 ± 2.81	7.11 ± 2.66			
	Overall	57	5.87 ± 2.82	6.87 ± 3.02	7.99 ± 2.64			
Bipod pinch	Group 1	23	3.84 ± 2.05	5.06 ± 2.35	5.76 ± 1.87	< 0.001**	0.076	0.021*
	Group 2	34	3.05 ± 2.08	3.50 ± 2.32	4.23 ± 2.21			
	Overall	57	3.37 ± 2.09	4.13 ± 2.44	4.85 ± 2.20			
Tripod pinch	Group 1	22	5.17 ± 2.63	6.16 ± 2.47	7.28 ± 2.14	< 0.001**	0.612	0.033*
	Group 2	34	3.79 ± 2.49	4.79 ± 2.82	5.58 ± 2.74			
	Overall	56	4.33 ± 2.61	5.33 ± 2.75	6.25 ± 2.63			
9HPT	Group 1	23	25.58 ± 8.53	20.42 ± 4.95	18.97 ± 4.68	< 0.001**	0.092	0.044*
	Group 2	34	32.14 ± 13.34	23.67 ± 7.39	20.20 ± 5.29			
	Overall	57	29.50 ± 12.00	22.36 ± 6.66	19.71 ± 5.04			

9HPT: Nine-hole Peg Test; *: $P < 0.05$; **: $P < 0.01$.

Table 2
Comparison of the DASH and TSK scores in both groups at the three follow-up assessments.

		n	1st time	2nd time	3rd time	Time	Time × Group	Group
DASH	Group 1	24	23.58 ± 18.41	20.15 ± 18.28	11.30 ± 11.68	< 0.001**	0.465	< 0.001*
	Group 2	34	47.29 ± 18.92	39.26 ± 15.91	30.85 ± 14.95			
	Overall	58	37.72 ± 21.95	31.55 ± 19.23	22.96 ± 16.7			
TSK	Group 1	24	37.72 ± 7.21	35.13 ± 6.69	32.31 ± 5.14	< 0.001**	0.091	0.024*
	Group 2	34	39.14 ± 5.75	38.38 ± 4.63	37.08 ± 6.06			
	Overall	58	38.58 ± 6.34	37.10 ± 5.70	35.21 ± 6.14			

DASH: Disabilities of Arm, Shoulder and Hand; TSK: Tampa Scale for Kinesiophobia. *: $P < 0.05$; **: $P < 0.01$

the functional outcomes in patients with finger tendon repairs. Patients who started using their hand during light daily activities from the end of the 5th postoperative week had a worse functional recovery than those who started at the end of the 6th week. Our clinical observation was that daily use of the hand 1 week earlier accelerates the functional recovery; however, this recovery did not improve the patient's objective functional status.

Tendon rehabilitation protocols in the literature include splint use for postoperative protection of the surgical repair. Splint use is recommended for 6 to 8 weeks to reduce the risk of rupture or gap formation, depending on the protocol. In the early passive mobilization protocol for this study, patients use a splint for the first 6 weeks during the whole day [1]. Despite the recent advances in the surgical suture techniques and the increase in the suture strength, early passive mobilization remains the preferred method in hand therapy due to the lower risk of rupture [12]. We also prefer early passive mobilization in our clinical practice. However, we realized that patients experience clumsiness and avoid using their hand even after splint removal. Therefore, we thought to accelerate our treatment protocol in an agreement with our surgical team and to assess its effect. Parallel to the finding that many therapists choose to modify the standard protocols, we also modified the early passive mobilization protocol and allowed patients to start using their hand earlier [12]. Subjectively, we observed that patients use their hand better after earlier splint removal. However, the results of this study have refuted our hypothesis because the modification did not further improve the patient's objective functional status. This result can be interpreted as the physiological process of tendon healing continuing, and the observational functional recovery does not always reflect the real healing process. Despite the functional improvement we observed, it appears that early intervention in the physiological healing process does not positively contribute to the objective results.

Kinesiophobia is the avoidance of moving a body part due to the fear of re-injury and/or pain [4]. A previous study reported that patients with upper extremity injuries have kinesiophobia and catastrophic thinking [13]. Parallel to this study's results, we also observed that patients experience clumsiness and hesitate to use their injured hand even after splint removal. Moreover, in our previous study, we had shown that a significant portion of patients with tendon repairs have high levels of kinesiophobia and that this may contribute to disability [3]. In accordance with that finding, we showed that kinesiophobia decreased with daily use of hand for a few weeks in this study. Therefore, patients can be encouraged to use their hand after the completion of the critical post-surgical period to overcome the fear avoidance behavior.

Our results should be interpreted carefully due to some limiting points. Firstly, we included both flexor and extensor tendon repairs in the study as our primary aim was to assess the effect of earlier splint removal on kinesiophobia. Future studies focusing only on flexor or extensor repairs may be more relevant. Secondly, we did not measure the range of motion as it does not reflect the functional status of the hand. Instead, performance-based tools and patient-reported outcomes were more important in capturing the functional recovery.

5. Conclusion

Splinting may cause kinesiophobia and hesitation when using the affected hand even after splint use has been discontinued. Despite the clinical observation that earlier use of the hand in daily life contributes to better functional recovery, quantitative functional outcome measures do not confirm this observation.

Disclosure of Interest

The authors declare that they have no competing interest.

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Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

Acknowledgements

The authors thank to Seda Kuşçu Özbudak, a brilliant member of the academic writing centre of Gazi University, for her kind language editing. She has approved to be acknowledged in this manuscript.

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