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Hand function response to static progressive splinting in post-burn finger contracture

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Abstract

Introduction. Restoring hand function is an important determinant of the quality of life in victims of burns. The purpose of the study was to determine the changes in the functional outcome when applying a flexion static progressive splint on the metacarpophalangeal joints of the contracted fingers after a burn injury.

Methods. This study included 60 patients referred to the hand therapy clinic 6 months after the injury. They presented with a burn on the dorsal portion of the hand with limited flexion range of motion in the metacarpophalangeal joints. The participants were randomly assigned to 2 groups (30 patients each). Group A (splint group) were treated with custom-made static progressive flexion splints. Additionally, they received physical therapy and medical treatment throughout the study period (8 weeks). Group B (control group) received physical therapy and medical treatment only. The burned hand was evaluated before and after treatment by measuring the metacarpophalangeal passive range of motion, determining grip strength, and employing the Jebsen-Taylor hand function test to assess the overall hand function.

Results. A statistically significant increase in all variables occurred in both groups after the intervention, with a higher increase in group A. In groups A and B, the p-values of passive range of motion were 0.001 and 0.784, of grip strength 0.023 and 0.608, and of Jebsen-Taylor hand function test 0.048 and 0.411, respectively.

Conclusions. Static progressive splint coupled with physical therapy can optimally improve hand function in patients with restricted metacarpophalangeal flexion passive range of motion after burn injuries.

Key words: hand function, post-burn contracture, static progressive splinting

Introduction

Although all body parts remain subjected to burn injury, hands are most commonly affected [1, 2]. According to the latest studies, hands are involved in 80% of burn injuries owing to their anatomical position in the body [1]. The hand is among the most frequent sites of scar contracture deformity after burns [3–8]. Deformities occur when appropriate treatment is not provided in acute situations or when the hand is severely injured [8, 9].

Loss of passive range of motion (PROM) in the metacarpophalangeal (MCP) joints after burns is primarily due to scar formation and the subsequent adaptive soft tissue shortening [10]. At the level of cells, the disruption of collagen synthesis and formation of periarticular collagen cross-bonds resulting from immobility and lack of physical stress contribute to joint stiffness [11, 12]. Also, the development of dorsal MCP joint contracture is common because of the tendency of the collateral ligament and joint capsule to contract [13]. This puts the hand in a functionally negative position of wrist extension, MCP joint extension, proximal inter-phalangeal joint flexion, and adduction of the thumb, leading to severe hand function loss [14].

The primary treatment approach to contracture deformity is to counteract the muscle shortening and prevent further damage by corrective splints in an anti-deformity position [15]. Mobilizing splinting is commonly applied by hand therapists to improve movement in the stiff joints [8, 16]. Splinting provides a function of holding the stiff joint at the end of the available range of motion (ROM) under constant light tension for prolonged periods [17].

Both dynamic and static progressive splints (SPSs) are considered to be mobilizing splints [18]. However, many clinicians believe that SPS is more beneficial than a dynamic splint to improve ROM in stiff joints [10, 18].

The potential benefits of SPS application are obtained through using non-elastic components (e.g., hook and loop tapes, non-elastic strings, progressive hinges, turnbuckles, pins, and gears) to apply torque to a joint in order to constantly put it to the end range as tolerable and thus increase PROM. SPS is simple to use and allows progressive adjustment in joint angles whenever PROM improves, without modification in the structure of the splint [10].

The need for this study was developed from the shortage of quantitative knowledge and information in the published studies about the effect of SPS on hand burn contractures to gain more PROM in the fingers. Thus, the study was conducted to determine the therapeutic effect of applying SPS to improve hand function in post-burn contracture of fingers.

Subjects and methods

Study design and subjects

This randomized controlled trial was conducted in a hand therapy centre located in Cairo, from June 2019 to November 2020. Overall, 60 patients who had burns on the dorsal

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portion of the hand with a limited flexion range in the MCP joints participated in this study. The patients had completed their initial acute treatment and were referred to the hand therapy clinic for rehabilitation. Only individuals who had contractures within 6–12 months after the injury were involved in the study. The patients, from both sexes, were aged 20–40 years. All had grade I or II restriction in PROM in accordance with McCauley's classification of hand burn scar contracture. Patients with 4th degree burns, musculoskeletal diseases in the injured hand (e.g., fractures, rheumatoid arthritis, or degenerative joint disease), or an accompanying finger tendon cut or repair were excluded from the study. The subjects who met the inclusion criteria were randomly divided into 2 equal groups: the splint group (A) and the control group (B). All patients were informed about the materials, objectives, and execution of the study.

Procedures

Measurements

The MCP joint (2nd through 5th finger) PROM was measured by using a Jamar Flexion Hyperextension Finger Goniometer (professional-grade manual finger ROM tool for accurate angle measuring) marked with 30° of hyperextension to 120° of flexion in 1° increments. The following dorsal bony landmarks were assigned to evaluate the MCP joint: fulcrum – over the MCP joint; long arm – over the midline of the proximal phalanx; short arm – over the midline of the metacarpal.

Grip strength was quantified with a grip dynamometer. Each patient squeezed the grip handle maximally for 2–3 seconds. The highest force among 3 trials (with a timed rest break of 30 s between them) was chosen for analysis.

The participants' overall hand function was evaluated with the Jebsen-Taylor hand function test (JHFT). It is a standardized test for assessing 7 subtests that simulate activities of daily living [19]. The 7 subtests of JHFT, in the order they were administered, included writing, turning over 3 × 5" index cards (simulated page-turning), picking up small common items, simulated feeding, stacking card games, grasping large light items, and grasping large heavy items. These subtests provide a general representation of daily living tasks. The total score was the sum of time taken for each subtest, rounded to the nearest second. Shorter times indicate better performance.

All the variables were tested for each group twice, before and after the applied program (8 weeks), for all the participants in the study.

Intervention

Group A (SPS + physical therapy program). A total of 30 patients received customized static progressive flexion splints. The splint was made of thermoplastic material and contoured to the volar aspect of the patient's hand and forearm. It extended from the proximal palmar crease to the middle of the forearm, putting the wrist joint in 30° extension. A perforated outrigger, made of the same material, was melted to the palmar part of the splint. Four leather finger cuffs contoured to each finger proximal phalanx were connected to the respective four 0.7-mm fishing line pieces passing through the corresponding holes in the outrigger. Each fishing line was tied with a piece of Velcro loop to be attached to the Velcro hook pieces that extended from the middle to the proximal

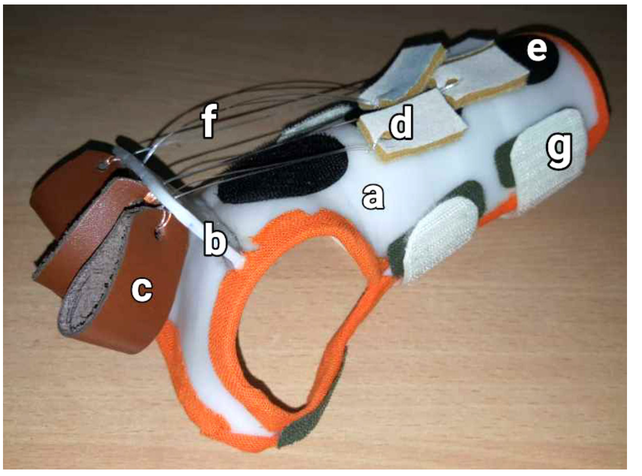

Figure 1. The components of the custom-made static progressive splint: (a) thermoplastic volar splint, (b) outrigger, (c) finger cuff, (d) Velcro loop, (e) Velcro hook, (f) fishing line, (g) Velcro strap

Figure 2. Fitting of the static progressive splint

part of the splint. The splint was secured to the forearm and hand by Velcro straps extended dorsally. Figure 1 shows the components of the SPS used in this study.

The splint was fitted securely, and the fingers were pulled proximally via the fishing line to be held in the most proximal tolerable position by using the Velcro hooks and loops (Figure 2). The patients were asked to increase the pull of each finger afterward as much as they could tolerate. The splint was worn intermittently, in accordance with a schedule.

Each participant also received a physical therapy program (stretching exercises and strengthening exercises) and medical treatment, which consisted in rubbing pure polysiloxane silicone gel as a management of hypertrophic scars and keloid, twice daily, throughout the 8 weeks of the study. The splint was applied for 30 minutes per treatment session, 3 times a week. Additionally, as a daily home program, the patients were instructed to put on the splint 2–5 times per day. Under the therapist's guidance, the subjects could increase the MCP joint flexion torque to a tolerable pain level by proximally pulling the fishing line when the splint was placed on.

Group B (control group). This group included 30 hand-burned patients who received their physical therapy program and medical treatment throughout the study period (8 weeks).

Physical therapy program for both groups. (a) Stretching exercises for each MCP joint, 2nd through 5th finger, were applied individually to tolerable flexion and held for 20 seconds. This exercise was performed multiple times during each session by the therapist for 15 minutes. (b) Strengthening exercises involved a handgrip exerciser, in the form of light to medium resistance Digiflex® hand exerciser tool, depending on the patients' ability to squeeze and hold it for 10 seconds, 20 repetitions during a session, and 20 repetitions every hour daily at home.

Statistical analysis

The SPSS v. 19.0 software (IBM Inc., USA) was used. Comparison between data in the 2 groups was performed with the Mann-Whitney test, and the Wilcoxon signed-rank test was applied to assess within-group changes in ROM and grip strength variables.

The paired *t*-test served to evaluate changes in JHFT scores within each group, and a comparison between data in the 2 groups was performed with the unpaired *t*-test. The value of $p < 0.05$ indicated significant results.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethical Committee at the Faculty of Physical Therapy, Cairo University, Egypt (approval No.: P.T.REC/012/002229).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

As can be observed in Table 1, there were no significant differences between the groups in the mean age values, gender distribution, or duration of burn injury before the intervention commencement (age: $p = 0.156$; gender: $p = 0.592$; duration of injury: $p = 0.841$).

Table 1. Demographic data of the 2 studied groups

Variables	SPS group (*n* = 30)	Control group (*n* = 30)	*p*
Age (years) [mean ± *SD*]	32.03 ± 5.22	29.93 ± 6.06	0.156
Gender (F:M) [*n* (%)]	12:18 (40%:60%)	10:20 (33.3%:66.7%)	0.592
Duration of illness (months) [mean ± *SD*]	8.80 ± 1.79	8.70 ± 2.04	0.841

SPS – static progressive splint, F – female, M – male
$p > 0.05$ – not significant

The intra-group comparison between the 2 studied groups revealed that there were significant post-treatment increases in passive flexion ROM, grip strength, and JHFT scores in both groups when compared with the corresponding pre-treatment values (ROM: $p = 0.0001$ in both groups; grip strength: $p = 0.001$ in both groups; JHFT: $p = 0.0001$ in the splint group and $p = 0.001$ in the control group). However, the inter-group comparison demonstrated a statistically significant difference in all measured post-treatment variables in favour of the splint group (ROM: $p = 0.001$; grip strength: $p = 0.023$; JHFT: $p = 0.048$) (Table 2, Figures 3–5).

Discussion

The study aimed to determine the therapeutic effect of applying SPS to improve hand function in patients with post-burn contractures. The splint group participants received customized static progressive flexion splints, physical ther-

Table 2. Inter- and intra-group comparison of different variables in the 2 studied groups measured before and after treatment

Variables	SPS group (*n* = 30)	Control group (*n* = 30)	*p**
MCP flexion PROM (°)			
Pre-treatment	15.0 (0.0–55.0)	17.5 (0.0–70.0)	0.784
Post-treatment	40.0 (9.0–73.0)	30.0 (0.0–80.0)	0.001†
p (pre vs. post within the same group)	0.0001	0.0001	
Grip strength (kg)			
Pre-treatment	5.0 (0.0–15.0)	5.0 (0.0–15.0)	0.608
Post-treatment	11.5 (2.0–20.0)	8.0 (0.0–19.0)	0.023†
p (pre vs. post within the same group)	0.001	0.001	
JHFT (s)			
Pre-treatment	144.63 ± 36.87	152.70 ± 38.56	0.001†
Post-treatment	122.83 ± 36.10	142.77 ± 40.15	0.048†
p (pre vs. post within the same group)	0.0001	0.001	

Data are expressed as median (min–max) or mean ± *SD*.
SPS – static progressive splint, MCP – metacarpophalangeal joint, PROM – passive range of motion, JHFT – Jebsen-Taylor hand function test
$p > 0.05$ – not significant, $p \leq 0.05$ – significant
* between-group comparison, † significant value

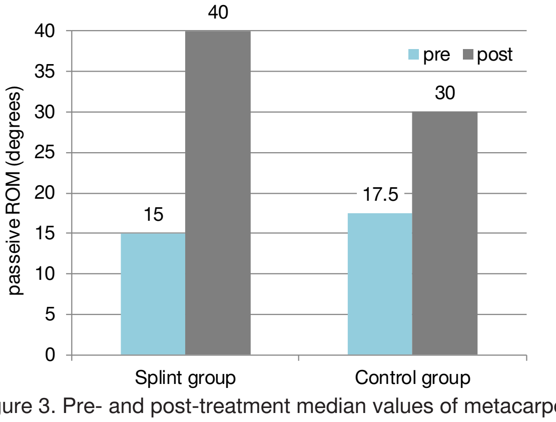

Figure 3. Pre- and post-treatment median values of metacarpophalangeal flexion passive range of motion (ROM) in both groups

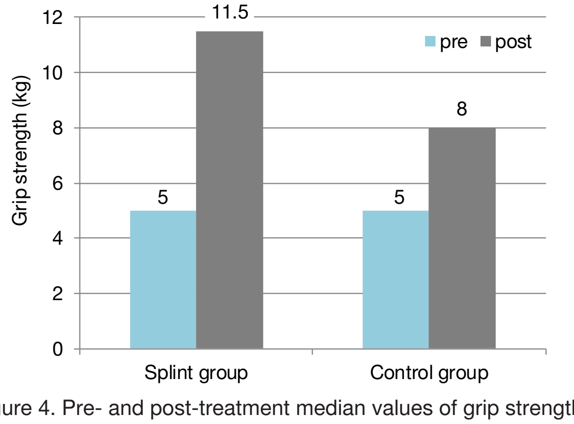

Figure 4. Pre- and post-treatment median values of grip strength in both groups

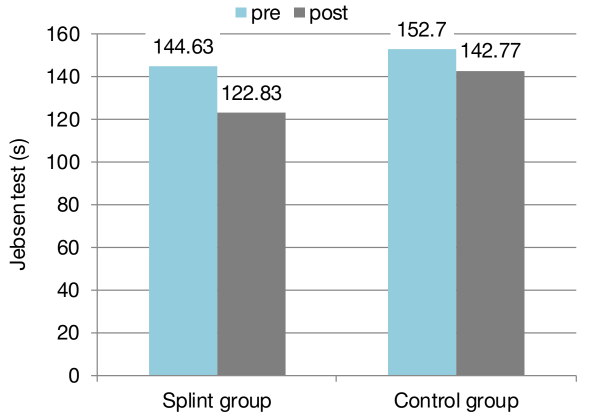

Figure 5. Pre- and post-treatment mean scores of Jebsen-Taylor hand function test in both groups

apy, and medical treatment throughout the study period (8 weeks).

Individuals after a dorsal hand burn exhibit MCP joints in extension and proximal inter-phalangeal joints in flexion, which is not the functional position of the hand. The concept of SPS function is to put the shortened tissues at a maximally prolonged low-load stress in order to enhance tissue lengthening [17]. The customized SPS used in this study keeps the wrist extended at 30°. The fishing line attached to the finger cuff applies progressive flexion torque to increase PROM of the MCP joints. Also, the fixed outrigger added to the palmar side of the splint enhances the efficiency of the pulling force on the proximal phalanx.

The progressive pulling force provided by SPS was based on the patient's tolerance, with the least pain level. Also, SPS wearing duration was gradually increased. This ensured the patient's compliance with the splint.

The results of this study revealed that PROM increased statistically significantly in both groups after treatment, with a more significant raise in the splint group than in the control group. The percentage of PROM improvement in group A was 52.6%, while that in group B was 38.7%.

Such improvement in PROM can be explained with the biological principle of connective tissue remodelling that occurs over time in response to physical stress [20]. ROM increases by stretching the joint capsule and elongating the adaptively shortened musculotendinous unit. Thus, the effectiveness of SPS application to reduce post-burn contractures consists in the function of the applied torque, as well as the duration and frequency of the splint usage.

Another benefit of applying low-intensity, long-duration stretch, which was offered by SPS in this study, is the optimal ROM improvement without causing excessive load or further injury [21]. Additionally, the low-load prolonged stretch provided by mobilizing splints stimulates collagen reorganization, leading to PROM increase [14, 17, 18]. It therefore results in a relatively permanent lengthening of soft tissues, potentially owing to plastic deformation.

The findings of this study are in line with those of previous studies that examined the effects of SPS of different designs on restricted ROM after various hand injuries, such as crushed injuries and fractures [22, 23].

Regarding the grip strength, the presented results showed a significant post-treatment increase in its median values in both groups compared with the corresponding pre-treatment values ($p = 0.001$). However, the comparison between the 2 groups demonstrated a significant post-treatment difference in favour of the splint group ($p = 0.023$).

One potential reason for this finding, which was significantly noticed in patients who received strengthening exercise coupled with SPS, may lie in the capability of the finger flexors to contract through an increased active range after gaining increased PROM of MCP joints.

On the other hand, patients in the control group exhibited a smaller improvement in grip strength. That might be due to a lower progress in PROM. Thereby, the finger flexors contract partially through the limited available range.

A previous study was conducted by Wang et al. [22] to evaluate the benefits of applying custom-made SPS for stiff joint ROM after hand trauma. Their results revealed that the progress in active ROM was smaller than that in PROM. The authors attributed such outcomes to the active inhibition created by the capsular tightness and soft tissue contractures, and to the muscle weakness. They recommended adding strengthening exercises to the splinting approach.

JHFT was utilized to evaluate the functional outcomes before and after the intervention. The results of the current study showed a significant improvement in hand function among patients in both groups in terms of a reduction in time required to achieve specific tasks simulating daily living activities. Patients who received SPS associated with stretching and strengthening exercises presented a post-intervention change in their hand function by 15.07%. Those in the control group, who received only the stretching and strengthening exercise program, demonstrated a change in the hand function by 6.5%. These results were positively correlated with the improvement in ROM and grip strength noticed in both groups. This opinion is supported by Culicchia et al. [24], who stated that 'there is a strong correlation between the hand function and its strength. A low gripping force contributes to a decreased functional capability'.

However, the statistical comparison between the groups after the intervention showed a significant difference in favour of the splint group ($p = 0.048$).

Most patients involved in this study could not complete all task items of JHFT, especially those with a larger burn surface area extended to the elbow and shoulder. Therefore, the test was conducted on the subtest level in order to compare the pre and post outcomes. However, on a clinical basis, during the intervention course and as the improvement progressed, it was noticed that patients started to regain some functional capabilities which were not evaluated initially (before treatment). Also, it was observed that each patient in the study had adopted their own strategy in order to maximize the hand function and achieve independence in activities of daily living.

Limitations

This study was limited by a relatively small sample size.

Conclusions

SPS, when applied together with a regular physiotherapy regimen, can improve hand function in patients suffering from post-burn hand contractures via increasing PROM of finger MCP joints.

Recommendations

– SPS application should be incorporated in the rehabilitation protocols for hand burn.

– Further studies might increase the number of participants and involve different age groups to enhance generalizability.

– Future research should investigate the effect of SPS application in patients with contractures and joint restrictions lasting for more than 1 year after burn injury.

Acknowledgment

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Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

References

1. Lotfi M, Mirza Aghazadeh A, Davami B, Khajehgoodari M, Aziz Karkan H, Khalilzad MA. Development of nursing care guideline for burned hands. Nurs Open. 2020;7(4): 907–927; doi: 10.1002/nop2.475.
2. Li H-L, Deng Y-T, Zhang Z-R, Fu Q-R, Zheng Y-H, Cao X-M, et al. Evaluation of effectiveness in a novel wound healing ointment – crocodile oil burn ointment. Afr J Tradit Complement Altern Med. 2016;14(1):62–72; doi: 10.21010/ajtcam.v14i1.8.
3. Afifi AM, Mahboub TA, Fouad AI, Azari K, Khalil HH, McCarthy JE. Active range of motion outcomes after reconstruction of burned wrist and hand deformities. Burns. 2016;42(4):783–789; doi: 10.1016/j.burns.2016.02.004.
4. Rrecaj S, Hysenaj H, Martinaj M, Murtezani A, Ibrahimi-Kacuri D, Haxhiu B, et al. Outcome of physical therapy and splinting in hand burns injury. Our last four years' experience. Mater Sociomed. 2015;27(6):380–382; doi: 10.5455/msm.2015.27.380-382.
5. Fufa DT, Chuang S-S, Yang J-Y. Postburn contractures of the hand. J Hand Surg Am. 2014;39(9):1869–1876; doi: 10.1016/j.jhsa.2014.03.018.
6. Cowan AC, Stegink-Jansen CW. Rehabilitation of hand burn injuries: current updates. Injury. 2013;44(3):391–396; doi: 10.1016/j.injury.2013.01.015.
7. Sabapathy SR, Bajantri B, Bharathi RR. Management of post burn hand deformities. Indian J Plast Surg. 2010; 43(Suppl.):S72–S79; doi: 10.4103/0970-0358.70727.
8. Kelly BM, Berenz T, Williams T. Orthoses for the burned hand. In: Webster JB, Murphy DP (eds.), Atlas of orthoses and assistive devices, 5th ed. Philadelphia: Elsevier; 2019; 170–175.
9. Glasgow C, Tooth LR, Fleming J. Mobilizing the stiff hand: combining theory and evidence to improve clinical outcomes. J Hand Ther. 2010;23(4):392–401; doi: 10.1016/j.jht.2010.05.005.
10. Schultz-Johnson K. Static progressive splinting. J Hand Ther. 2002;15(2):163–178; doi: 10.1053/hanthe.2002.v15.015016.
11. Wong K, Trudel G, Laneuville O. Noninflammatory joint contractures arising from immobility: animal models to future treatments. Biomed Res Int. 2015;2015:848290; doi: 10.1155/2015/848290.
12. Akeson WH, Amiel D, Mechanic GL, Woo SL, Harwood FL, Hamer ML. Collagen cross-linking alterations in joint contractures: changes in the reducible cross-links in periarticular connective tissue collagen after nine weeks of immobilization. Connect Tissue Res. 1977;5(1):15–19; doi: 10.3109/03008207709152607.
13. Stewart KM. Therapist's management of the complex injury. In: Mackin EJ, Callahan AD, Skirven TM, Schneider LH, Osterman AL (eds.), Rehabilitation of the hand and upper extremity, 5th ed. St Louis: Mosby; 2002; 1411–1427.
14. Bhattacharya S. Avoiding unfavorable results in postburn contracture hand. Indian J Plast Surg. 2013;46(2): 434–444; doi: 10.4103/0970-0358.118625.
15. Pandya AN. Principles of treatment of burn contractures. Repair Reconstr. 2001;2:12–13.
16. Dewey WS, Richard RL, Parry IS. Positioning, splinting, and contracture management. Phys Med Rehabil Clin N Am. 2011;22(2):229–247; doi: 10.1016/j.pmr.2011.02.001.
17. Glasgow C, Fleming J, Tooth LR, Hockey RL. The longterm relationship between duration of treatment and contracture resolution using dynamic orthotic devices for the stiff proximal interphalangeal joint: a prospective cohort study. J Hand Ther. 2012;25(1):38–47; doi: 10.1016/j.jht.2011.09.006.
18. Glasgow C, Tooth L, Fleming J. Which splint? Dynamic versus static progressive splinting to mobilise stiff joints in the hand. Br J Hand Ther. 2008;13(4):104–110; doi: 10.1177/175899830801300401.
19. Mak MKY, Lau ETL, Tam VWK, Woo CWY, Yuen SKY. Use of Jebsen Taylor Hand Function Test in evaluating the hand dexterity in people with Parkinson's disease. J Hand Ther. 2015;28(4):389–395; doi: 10.1016/j.jht.2015.05.002.
20. Cummings GS, Tillman LJ. Remodeling of dense connective tissue in normal adult tissues. In: Currier DP, Nelson RM (eds.), Dynamics of human biologic tissues. Philadelphia: FA Davis; 1992; 45–73.
21. MacKay-Lyons M. Low-load, prolonged stretch in treatment of elbow flexion contractures secondary to head trauma: a case report. Phys Ther. 1989;69(4):292–296; doi: 10.1093/ptj/69.4.292.
22. Wang J, Erlandsson G, Rui Y-J, Li-Tsang C. Efficacy of static progressive splinting in the management of metacarpophalangeal joint stiffness: a pilot clinical trial. Hong Kong J Occup Ther. 2014;24(2):45–50; doi: 10.1016/j.hkjot.2014.07.001.
23. Michlovitz SL, Harris BA, Watkins MP. Therapy interventions for improving joint range of motion: a systematic review. J Hand Ther. 2004;17(2):118–131; doi: 10.1197/j.jht.2004.02.002.
24. Culicchia G, Nobilia M, Asturi M, Santilli V, Paoloni M, De Santis R, et al. Cross-cultural adaptation and validation of the Jebsen-Taylor Hand Function Test in an Italian population. Rehabil Res Pract. 2016;2016:8970917; doi: 10.1155/2016/8970917.