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Thumb carpometacarpal joint immobilization orthosis

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ABSTRACT

Background: A new design of thumb carpometacarpal joint immobilization orthosis for positioning and improving hand function. This orthosis stabilizes the thumb in the desired position when thenar muscles are weakened, first carpometacarpal joint pain, deformities, or other thumb problems. This orthosis frees the dorsum of the hand, covers the palm, curves and conforms to the thenar web space, and holds the thumb in opposition.

Objective: To study compliance and acceptance of patients with the new design thumb carpometacarpal joint immobilization orthosis that is easy to fabricate and reduces cost.

Materials and methods: This pilot study was set at the Occupational Therapy Unit, Department of Rehabilitation Medicine, Faculty of Medicine, Ramathibodi Hospital, Mahidol University. All twelve patients, including seven of first carpometacarpal joint arthritis, two Syringomyelia, two median nerve injuries, and one cerebral palsy, were asked to fill out a questionnaire designed for hand function and activities of daily living. In contrast, the thumb carpometacarpal joint immobilization orthosis was fabricated. After the patient had worn the new design orthosis for two weeks, they were asked to complete two questionnaires. One was hand function and activities of daily living, and the other was five items of patients' satisfaction with thumb carpometacarpal joint immobilization orthosis that was found out from the factors related to compliance with hand orthosis.

Results: After two weeks, all patients who applied a thumb carpometacarpal joint immobilization orthosis could improve the quality of writing, open doors, and pick up small coins. They all accepted thumb carpometacarpal joint immobilization orthosis to take turns applying with thumb spica because free space at the dorsum of the hand permitted them to move more flexibly with excellent support at the first carpometacarpal joint, letting them tolerate long-term activities.

Conclusion: The new thumb carpometacarpal joint immobilization orthosis focuses on thumb opposition and allows free movement of the wrist and meta-carpophalangeal joints, especially in the case of carpometacarpal joint arthritis who do not have a weak thumb. It can be substituted for another thumb opposition orthosis because of easy fabrication and reduced cost.

Introduction

The thumb is the most critical finger for performing hand functions and is involved in activities of daily living. Therefore, the opposition of the thumb is a complex and vital movement.[1,2] When we performed this position, the thumb pad should touch the pad of the other fingers.[2] The carpometacarpal and metacarpophalangeal joints of the thumb should move palmar abduction to expand the first web space for adequate opposition. This position worked with thenar muscles (abductor pollicis brevis, flexor pollicis brevis, and opponens pollicis).[2]

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The functional position of the thumb means that the thumb keeps palmar abduction of 45°, opposition, and maintains first web space for prehension in both active and passive movement.[2] Both permanent and temporary thumb carpometacarpal joint immobilization orthosis referenced the principle of orthosis to consider patients' anatomy, biomechanics, and compliance.[3-5] For median nerve injury, spinal cord injury (C6, 7 levels), cerebral palsy, and syringomyelia, patients with the weak thumbs (Figure 1) needed a thumb carpometacarpal joint immobilization orthosis with thumb support to promote more thumb stability. A group of carpometacarpal joint arthritis patients who could do thumb movement (Figure 2) have received a thumb carpometacarpal joint immobilization orthosis without thumb support for correcting joint deformities such as subluxation, hyperextension, deviation, and adduction contracture.

***Figure 1**. Ape hand deformity.*

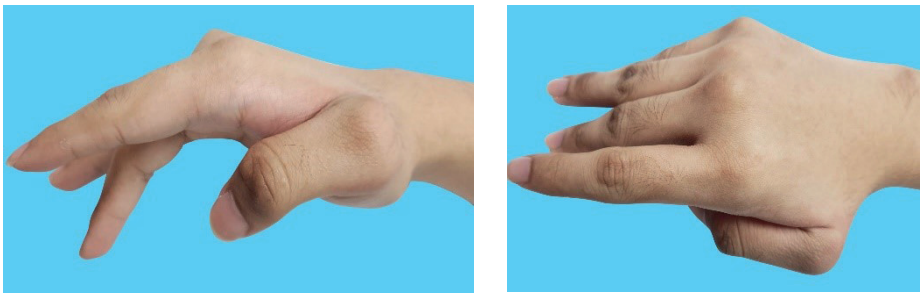

***Figure 2**. Thumb deformity.*

A common orthosis for most thumb problems was thumb spica[6] (butterfly pattern), which was very effective. Still, this orthosis took a long time to fabricate and needed a large area of thermoplastic (5"x 5"). Creating those orthoses can be challenging for therapists, especially for those who lack practical experience due to the complicated designs, patterns, and orthoses' requirements, which need to cover patients' volar and dorsum of hand and thumb areas. Additionally, therapists are often constrained by a tight time frame, typically having only 2-3 minutes to complete the process before thermoplastic is set. Usually, making one functional thumb orthosis requires the assistants to help set the position, and sometimes, it is necessary to adjust it until it fits patients' hands perfectly.

The patient's complaints regarding wearing butterfly pattern orthosis were the limited space in the thumb area, which makes it challenging to wear, especially in patients with wounds, sensitive skin, joint deformities, or muscle/ligament contracture. While wearing the thumb orthoses, patients might find them uncomfortable or painful at the dorsum of the hand when they do activities for a long time. The other is that the cost of orthosis is relatively high because it requires a large area of thermoplastic.

Therapists' problems while making butterfly pattern orthoses were difficulty setting the orthosis into the needed positions and excessive use of thermoplastic because many areas need to be cut off in the making process. For all these reasons, the researchers aim to invent a new design of "Thumb carpometacarpal joint immobilization orthosis" and study its effectiveness, patient satisfaction, and compliance.

Orthoses designs

Two patterns were used for this thumb orthosis design, shown in Figures 3 and 4. Therapists must consider providing patients with the appropriate and correct type of orthosis based on the following criteria.

The thumb orthosis pattern in Figure 3 is designed for patients who can perform thumb opposition movements, such as carpometacarpal joint arthritis, subluxation, deviation, and adduction contracture patients. This orthosis pattern strongly supports the first carpometacarpal joint. The therapist started fabricating a thumb carpometacarpal joint immobilization orthosis by preparing a 3"x 5" thermoplastic with 3.2-mm thickness, cut in a rectangle shape. Figure 5 shows the steps of making a carpometacarpal joint immobilization orthosis pattern.

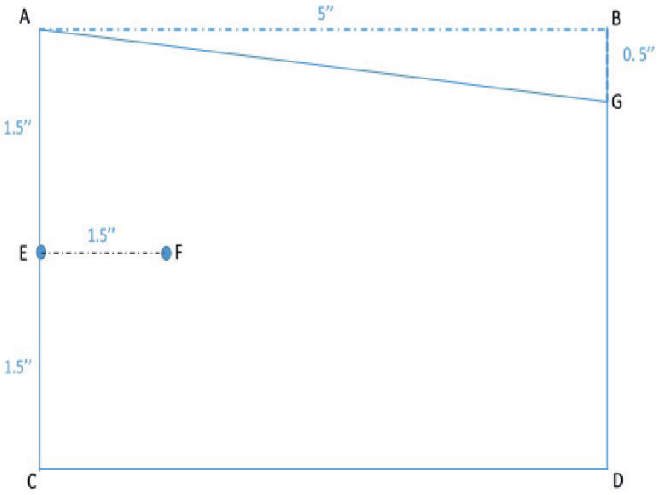

Figure 3. *Thumb carpometacarpal joint immobilization orthosis pattern.*

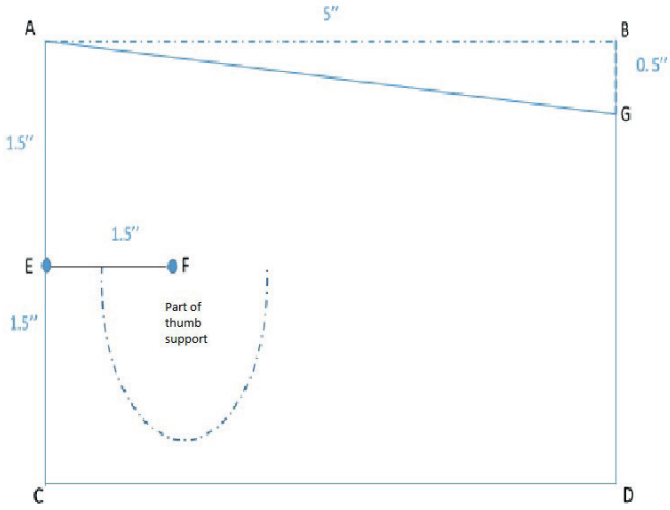

Figure 4. *Thumb carpometacarpal joint immobilization orthosis with thumb support pattern.*

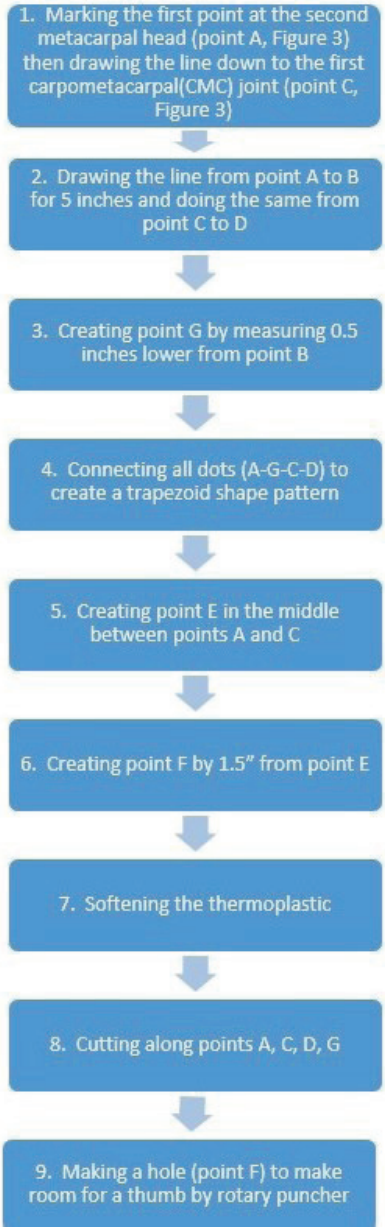

Figure 5. *Steps of making a pattern of thumb carpometacarpal joint immobilization orthosis.*

Materials and methods

Materials

1. Thermoplastic 3.2 mm. thickness (3”x 5”)
2. Velcro2” width loop
3. Velcro2” width adhesive hook
4. Rotator puncher
5. Scissors
6. Heat gun

Methods

The therapist should start by marking the first point at the second metacarpal head (point A, Figure 3) and then drawing the line down to the first carpometacarpal (CMC) joint (point C, Figure 3). After that, draw the line from point A to B for 5 inches and do the same from point C to D. Next, create point G by measuring 0.5 inches lower from point B and connecting all dots (A-G) to create a trapezoid shape pattern. Then, create point E in the middle between points A and C. Create point F by 1.5” from point E to get the perfect pattern of thumb carpometacarpal joint immobilization orthosis that could follow 1-9 steps (Figure 5). Softening the thermoplastic and cutting along points A, C, D, and G. The last process is punching point F to make room for a thumb by a rotary puncher.

The pattern of thumb orthosis was softened again, with the patient’s thumb in a designated hole and gently molding thermoplastic to set the thumb in an opposing position. While setting the position, therapists must ensure that the transverse arch of the hand maintains a normal angle. The medial side of this orthosis should extend to cover the medial border of the head and base of the 2nd metacarpal bone. In contrast, the ulnar side should encompass the ulnar border of the 5th metacarpal bone (Figure 6).

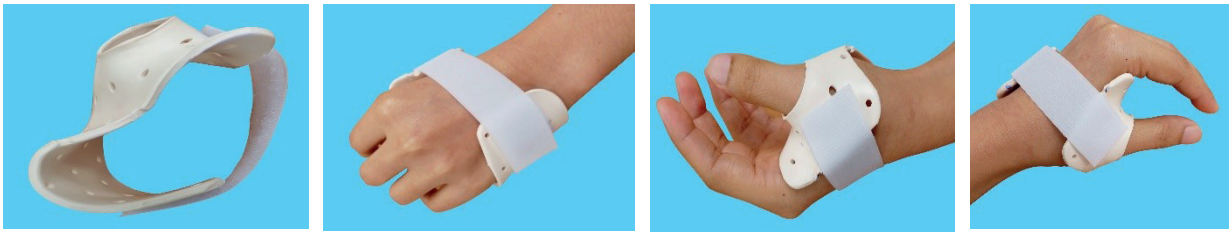

Figure 6*. The new design thumb carpometacarpal joint immobilization orthosis.*

Figure 4 demonstrates the pattern of thumb orthosis for patients who could not perform thumb opposition movement because of weakness or pain. This pattern was created to provide more support to set the thumb into the needed position than the Figure 3 pattern. For example, median nerve injury, spinal cord injury, stroke, degenerative joint disease, and syringomyelia patients. We started by drawing a pattern from 1-9 steps (Figure 5) and drawing half oval as thumb’s circumference size (base of thenar crease and radial side of the first metacarpal bone). Then pierced half of the oval circumference from the first metacarpophalangeal joint side. The therapist could set the position in thumb opposition, and the oval piece will help to correct and support the thumb in the needed position (free IP or pad of thumb) (Figure 7). Due to the less area of thermoplastic for thumb orthosis (3”x 5”) compared with thumb spica (5”x 5”), the cost of palmar thumb opposition orthosis is optimizing cost-effectiveness, it is around 40% lower than conventional butterfly pattern orthosis.

Wearing this orthosis is suggested both day and night.[7,8] During the daytime, patients must remove the orthosis every two hours. When removing the orthosis, patients should perform gentle stretching and exercises for half an hour to rest and prevent skin breakdown.

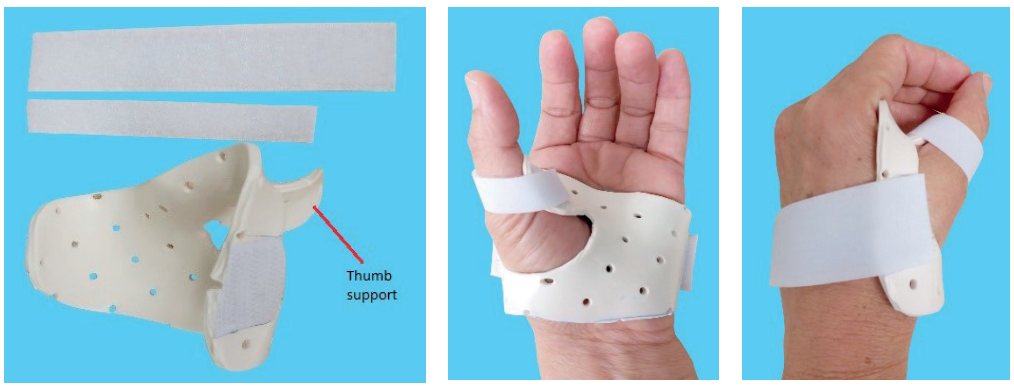

Figure 7*. The new design thumb carpometacarpal joint immobilization orthosis with thumb support.*

Participants

Patients who had thumb problems and needed thumb orthoses, both old and new patients, were purposefully recruited based on the following criteria. Inclusion criteria are based on the weakness of thumb muscles, ape hand deformity from various causes such as median nerve, muscle imbalance or carpometacarpal joint arthritis. All of them were willing to sign the agreement to be involved in this study. Exclusion criteria were the patients with mental illness, stiffness or deformity at the wrist or other joints of the hands, other muscle weakness except for thumb weakness, communication problems, and other thumb problems such as trigger thumb and rheumatoid arthritis.

Data collection

The therapist screens patients by gathering patient's data, providing the study details, and letting them sign the consent form. Then, interviews will be conducted with patients to collect their medical histories and a questionnaire on hand function and activities of daily living evaluation will be administered. Patients received the thumb orthosis within 20-30 minutes. Therapists let them wear it for two weeks. After two weeks, therapists will explore the patient's satisfaction and hand function results. Patients had to complete a questionnaire about hand function and activities of daily living evaluation and a questionnaire of about five items of satisfaction for thumb carpometacarpal joint immobilization orthosis.

Instruments

The research instruments in this study were a self-development questionnaire on hand function and activities of daily living evaluation (Appendix 1), and a questionnaire on patients' satisfaction with thumb carpometacarpal joint immobilization orthosis assessed all patients' problems while wearing orthosis and factors related to compliance with hand orthosis in our clinic. (Appendix 2)

Data analysis

Descriptive statistics presented the mean and standard deviation of the participant's demographic data and hand function questionnaire.

Venue of study

Occupational therapy outpatient unit, Department of Rehabilitation Medicine, Faculty of Medicine, Ramathibodi Hospital, Mahidol University by January-August 2019.

Results

Twelve patients were involved, resulting in the fabrication of sixteen thumb carpometacarpal joint immobilization orthoses. Eight males and four females were among these patients. The patient group comprised two individuals with Syringomyelia (both requiring both right and left orthoses), two patients with median nerve injuries, one with cerebral palsy, and seven suffering from carpometacarpal joint arthritis (two of them necessitating both right and left orthoses), as indicated in Table 1.

Table 1. Demographic characteristics of the patients (N=12).

Characteristic (N=12)		**N (%)**
Age (year)	Range 7-76	Mean (SD) 40.08 (SD)
Gender		
Male		8 (66.67%)
Female		4 (33.33%)
Disability		
Ape hand		4 (33.34%)
Spastic hand (thumb)		1 (8.33%)
CMC joint subluxation		7 (58.33%)
Diagnosis		
Syringomyelia		2
Median nerve injury		2
Cerebral palsy		1
Arthritis		7
Number of carpometacarpal joint immobilization orthosis		
Left side		2
Right side		10
Both side		4

Thumb carpometacarpal joint immobilization orthosis could help the patients to do more fine hand functions such as picking up small objects, opening doors by using keys, and writing, especially when patients do those activities for a long time because of free space at the dorsum of the hand. It is essential to set the thumb position as normal as possible while doing thumb opposition movement, which helps them do more instrumental daily activities, as shown in Figure 8. Only one cerebral palsy child did not have better hand function, but her hand position was better.

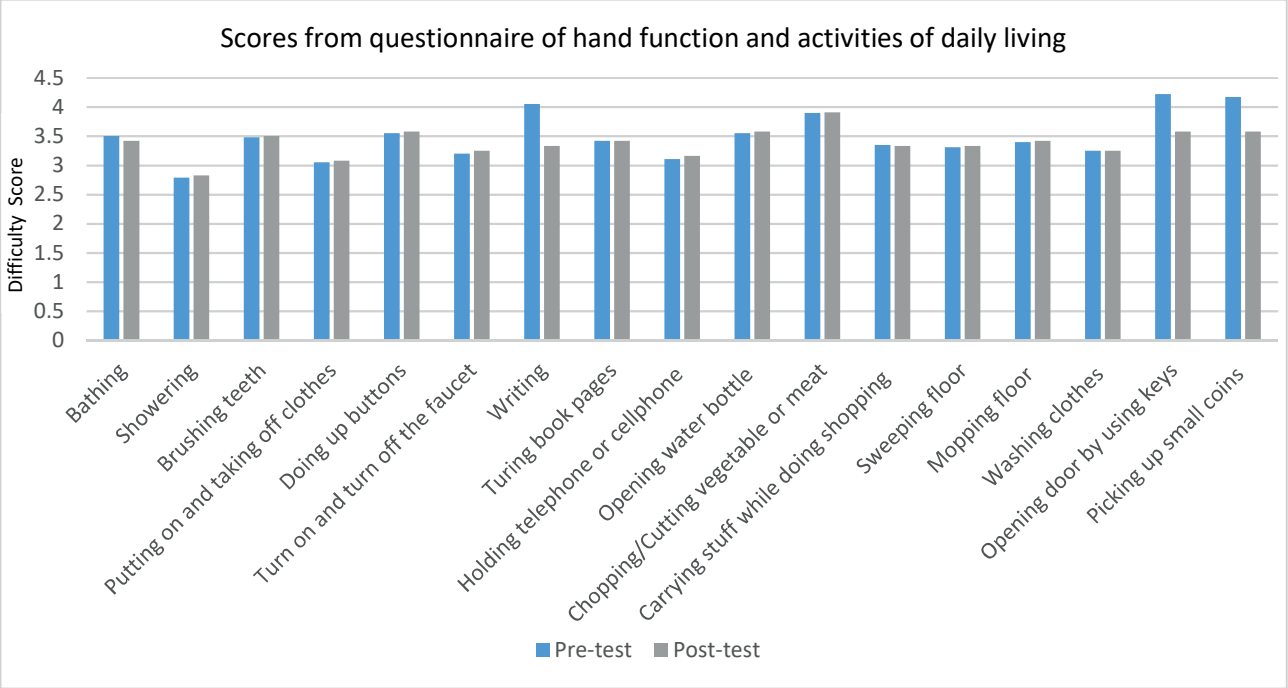

Figure 8*. Comparison between pre-test and post-test questionnaires of hand function and activities of daily living (N=12). 1: no difficulty, 2: a little bit of difficulty, 3: moderate difficulty, 4: quite a bit of difficulty, 5: extreme difficulty or unable to perform activities*

Carpometacarpal joint arthritis patients can apply thumb carpometacarpal joint immobilization orthosis without thumb support. They could move their thumb independently and feel free in the dorsum of their hands compared to previous thumb spica. For weak thumb patients, this thumb orthosis with thumb support and a free thumb pad, patients' thumb stability enabled them to do more movement.

There were seven carpometacarpal joint arthritis that applied thumb carpometacarpal joint immobilization orthosis without thumb support (Figure 6) correctly. Another patient applied thumb carpometacarpal joint immobilization orthosis with support (Figure 7). Notably, all seven carpometacarpal joint arthritis patients were previously accustomed to a different pattern of thumb orthoses. However, after trying the thumb carpometacarpal joint immobilization orthosis, they unanimously preferred it for three primary reasons. Firstly, this orthosis provided exceptionally robust support. Secondly, it effectively established and corrected the thumb's carpometacarpal joint deformities. Lastly, it was easy for the patients to apply this orthosis independently. Notably, all patients reported that the aspect they liked the most about wearing the thumb carpometacarpal joint immobilization orthosis was experiencing less pain, particularly those who had previously used other types of thumb orthoses, as demonstrated in Table 2.

Table 2. Scores from a questionnaire of patients' satisfaction with thumb carpometacarpal joint immobilization orthosis (N=12).

No.	The number of answered items				
	Difficulty of wearing	Pain while wearing	Hand function while wearing	Follow doctor's advice	Valuable
1	6	8	8	9	8
2	8	9	8	10	8
3	7	9	9	10	7
4	2	9	7	8	10
5	10	10	7	10	10
6	10	10	7	8	10
7	10	10	10	10	10
8	10	8	8	5	8
9	6	10	9	9	7
10	9	10	8	10	9
11	8	9	8	9	9
12	6	8	8	8	8
MD	8	9	8	9	8.5
SD	7.67	9.16	8.08	8.83	8.67

Discussion

Orthosis is a standard conservative treatment for first carpometacarpal joint problems, providing pain relief, joint positioning, and hand function.[9] This thumb carpometacarpal joint immobilization orthosis is an immobilization orthosis applied from many thumb orthosis patterns[10-12] for patients' comfort. Previous studies explained the effectiveness of palmar thumb opposition orthosis in various aspects.[8]

A therapist can use many patterns of thumb opposition orthosis[1,10] to select the appropriate one for the patient. In our routine work, the therapist gave thumb spica (butterfly pattern) to thumb problem patients, and the effectiveness of this orthosis was agreed upon.[3] However, for patients, the most critical concerns of orthosis were cost-effectiveness and comfort, so therapists tried thumb carpometacarpal joint immobilization orthosis to solve these problems. The pattern of thumb spica covered both the carpometacarpal joint and the metacarpophalangeal joint, even in unnecessary cases.

The results showed that a group of patients with carpometacarpal joint arthritis improved three activities of daily living (writing, opening doors by using keys, and picking up tiny coins). These three activities of daily living caused pain at the carpometacarpal joint. Strong support and sound position for more stability of carpometacarpal joint immobilization orthosis could solve pain problems and cause less difficulty while doing those activities.

Another group of patients consists of two Syringomyelia, two median nerve injuries, and one cerebral palsy. They were all severe and chronic cases. There was not much change as a result.

Conclusion

All the patients who had differently used different thumb orthoses expressed high satisfaction after transitioning to the thumb carpometacarpal joint immobilization orthosis, particularly those suffering from first carpometacarpal osteoarthritis with pain and/or subluxation. Patients cited several reasons for their contentment. First and foremost, the orthosis offered excellent support for the first carpometacarpal (CMC) joint by the medial and lateral aspects, while the lateral aspect of the thumb spica was Velcro. Additionally, it provided ample space on the dorsum of the hand and resulted in less pressure.

From therapists' perspectives, these two orthoses' patterns proved time-efficient and had simpler designs than the older alternatives. Furthermore, these designs were cost-effective since they required less thermoplastic material for fabrication. The thumb carpometacarpal joint immobilization orthosis is proper for thumb problems. It is suitable for therapists to have a variety of thumb orthoses for patients.

Limitation

One limitation of this thumb carpometacarpal immobilization orthosis was the difficulty in facilitating certain functions that require a flat palm, such as holding large and heavy objects and pushing the door open.[11] This challenge arises from the intricate and complex movements of the thumb, which make it unique and crucial for hand function. Thence, therapists must consider the details of thumb anatomy and kinesiology.[1]

Another limitation was that one question about pain in a satisfaction questionnaire about the thumb carpometacarpal joint immobilization orthosis might confuse patients. The score was converted to the pain score. Accordingly, therapists must describe pain clearly to patients before completing this questionnaire.

The last limitation was the lack of validity and reliability of both questionnaires about patients'

satisfaction with palmar thumb opposition orthosis and the questionnaire on hand function and activities of daily living evaluation in the Thai version.[8,12] This thumb carpometacarpal joint immobilization orthosis was also studied in a small group of patients. Further research about palmar thumb opposition, questionnaires on hand function and activities of daily living, and a satisfaction questionnaire about the thumb carpometacarpal joint immobilization orthosis were necessary.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

Funding

None

Ethics consideration

This study was approved by the Human Research Ethics Committee, Faculty of Medicine, Ramathibodi Hospital, Mahidol University (Approval ID: COA NO. MURA2018/956)

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Appendix 1

<u>แบบสอบถามเพื่อประเมินการใช้งานมือ</u>

แบบสอบถามนี้ใช้เพื่อประเมินการใช้มือของท่านในการทำกิจวัตรประจำวันและทำงานบ้าน
โปรดตอบแบบสอบถามทุกข้อโดยทำเครื่องหมาย ✓ ในช่อง

กิจกรรม	ทำได้ตามปกติ (1)	ทำได้ด้วยความลำบากเล็กน้อย (2)	ทำได้ด้วยความลำบากปานกลาง (3)	ทำได้ด้วยความยากลำบากมาก (4)	ไม่สามารถทำได้ (5)
1. การอาบน้ำ					
- ใช้ขันตักอาบ					
- ใช้ฝักบัว					
2. การแปรงฟัน					
3. การถอด-ใส่เสื้อผ้า					
4. การกลัด-ถอดกระดุมเสื้อผ้า					
5. การเปิด-ปิดก๊อกน้ำหัวเกลียว					
6. การเขียนหนังสือ					
7. การพลิกหน้าหนังสือพิมพ์หรือพลิกหน้ากระดาษ					
8. การถือหูโทรศัพท์บ้านหรือถือโทรศัพท์มือถือเพื่อใช้งาน					
9. การเปิด-ปิดฝาเกลียวขวดหรือฝาเกลียวภาชนะ					
10. การหั่นผักหรือหั่นเนื้อสัตว์					
11. การถือหรือหิ้วของขณะช้อปปิ้งหรือขณะใช้งาน					
12. การทำงานบ้านได้แก่ - กวาดบ้าน - เช็ดบ้าน - ซักผ้า					
13. การจับกุญแจไขเปิดประตู					
14. การหยิบจับเหรียญบาท					

Appendix 2

แบบสอบถามความพึงพอใจของผู้ป่วยที่มีอาการอ่อนแรงของนิ้วหัวแม่มือและเกิด **ape hand deformity** ต่อการใช้อุปกรณ์พยุงนิ้วหัวแม่มือแบบ **palmar opposition splint**

โปรดกาเครื่องหมาย X ลงในช่องคะแนนที่ท่านคิดว่าตรงกับตัวท่านมากที่สุด

1 ท่านสวมใส่ และถอดอุปกรณ์พยุงนิ้วหัวแม่มือด้วยตนเองได้ยากง่ายเพียงใด?

0	5	10
ยาก		ง่าย

2 อุปกรณ์พยุงนิ้วหัวแม่มือทำให้ท่านเกิดความรู้สึกเจ็บปวด หรือไม่?

0	5	10
เจ็บปวดมาก		ไม่เจ็บปวดเลย

3 เมื่อท่านใส่อุปกรณ์พยุงนิ้วหัวแม่มือท่านสามารถใช้งานมือข้างที่ใส่อุปกรณ์พยุงนิ้วหัวแม่มือได้มากน้อยเพียงใด?

0	5	10
ใช้ไม่ได้เลย		ใช้ได้ตามปกติ

4 ท่านสามารถใส่อุปกรณ์พยุงนิ้วหัวแม่มือตามระยะเวลาที่แพทย์กำหนดได้หรือไม่?

0	5	10
ไม่ได้เลย		ได้ %100

5 ท่านคิดว่าอุปกรณ์พยุงนิ้วหัวแม่มือมีประโยชน์ต่อท่านมากน้อยเพียงใด?

0	5	10
ไม่มีประโยชน์		มีประโยชน์มาก