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Journal of Hand Surgery Global Online

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Original Research

## Metacarpal Abduction Orthosis for Patients With the Thumb Carpometacarpal Osteoarthritis

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## ARTICLE INFO

**Article history:**

Received for publication July 24, 2019

Accepted in revised form January 31, 2020

Available online March 7, 2020

**Key words:**

Carpometacarpal joint

Hand

Musician

Orthosis

Osteoarthritis

**Purpose:** A specific orthosis to increase radial abduction of the metacarpal of the thumb rather than immobilize it was designed for patients with carpometacarpal (CMC) joint osteoarthritis. This orthosis was designed especially for musicians, who need a large abduction angle of the thumb CMC joint to maintain their hand span to perform music.

**Methods:** The thumb abduction orthosis was custom-made of flexible polypropylene, leaving the thumb metacarpophalangeal and wrist joints unrestricted and compressing the ulnar side of the thenar muscle to increase the radial abduction angle of the thumb metacarpal. Hand span and grip strength were measured, and clinical symptoms were assessed with the visual analog scale and *Quick-Disabilities of the Arm, Shoulder, and Hand* score. The Tubiana and Chamagne score was used to assess musical performance.

**Results:** A total of 23 thumbs of 19 professional musicians with CMC joint osteoarthritis were placed in an orthosis. The radial abduction angle of the thumb CMC joint, grip strength, and hand span were significantly increased or enlarged after bracing. Clinical symptoms evaluated by visual analog score, *Quick-Disabilities of the Arm, Shoulder, and Hand* score, and Tubiana and Chamagne score also improved.

**Conclusions:** Placement of a metacarpal abduction orthosis improved the hand span and improved patient-reported outcomes.

**Type of study/level of evidence:** Therapeutic IV.

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Symptomatic hand osteoarthritis has been associated with difficulties in performing work tasks including performing music. The thumb carpometacarpal (CMC) joint, also called the thumb trapeziometacarpal joint, is a common site for disabling hand osteoarthritis, affecting up to 20% of men and women older than age 40.<sup>1–3</sup> Genetic, sex, environmental, and physiological factors have a role in the etiology, and it is especially prevalent among postmenopausal women.<sup>1</sup>

Conservative treatment of CMC osteoarthritis includes analgesics, joint protection, strengthening exercises of the intrinsic and extrinsic muscles of the thumb, assistive devices, and placement of

an orthosis.<sup>2–6</sup> The objective of using orthoses is to stabilize the CMC joint, providing pain control and preventing contracture, with the primary goal of preventing dorsal subluxation during pinch.<sup>1,6,7</sup> Egan and Brousseau<sup>1</sup> reviewed 2 types of orthoses: long opponens, including the wrist and thumb interphalangeal joint; and short opponens, based in the palm and extending only to the first metacarpophalangeal joint. They found no evidence that one type of orthosis was more effective than the other at providing pain relief or enhancing function.<sup>1</sup>

Although there are many variations in orthosis types, orthoses usually focus on immobilizing the CMC joint, focusing on opposition rather than radial abduction. Yet, arthritis causes an adduction contracture of the CMC joint, which decreases the radial abduction angle of the thumb and reduces the hand span, defined as the maximum distance between the fingertips of the thumb and the little finger.<sup>8</sup> Hand span is an important factor for musicians' hands, especially for pianists, who need to strike the 2 distant keys simultaneously with these 2 digits maximally abducted.<sup>9</sup> Orthotic

**Declaration of interests:** No benefits in any form have been received or will be received by the authors related directly or indirectly to the subject of this article.

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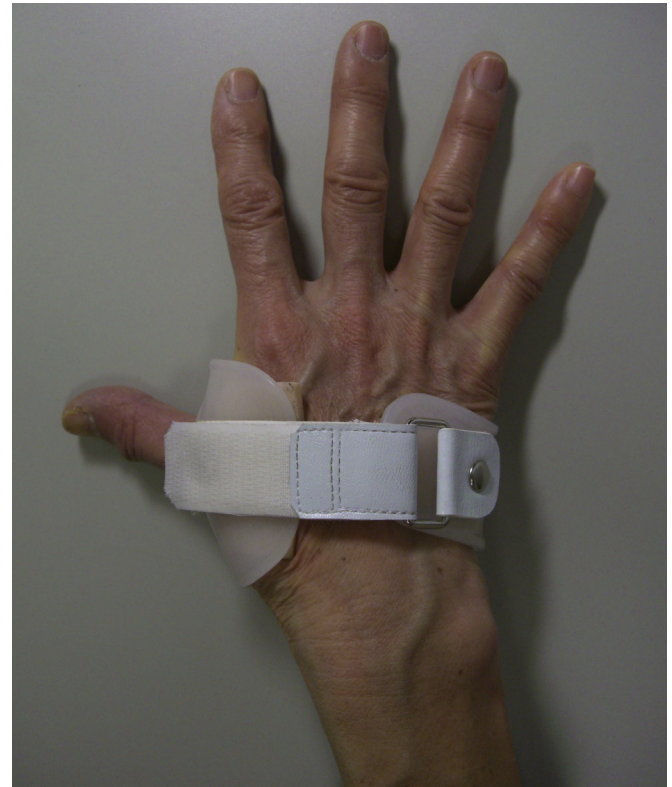
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<https://doi.org/10.1016/j.jhsg.2020.01.005>

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**Figure 1.** The thumb abduction orthosis was designed to compress the first metacarpal, increasing the radial abduction angle of the thumb.



**Figure 2.** Patients can regulate compressive pressure by tightening the band at the dorsal side.

immobilization limiting or decreasing the radial abduction angle of the CMC joint and reducing the hand span would thus be detrimental. Similarly, surgery with an arthrodesis or trapeziectomy with a central migration of the metacarpal would reduce the hand span, causing difficulties for the musician's occupational activities.<sup>10</sup>

The author has treated CMC joint osteoarthritis in musicians with radial abduction exercises of the CMC joint to enlarge the hand span, and noticed that these exercises resulted in increases in abduction angle and improvement in clinical symptoms including CMC joint pain. On the basis of this experience, the author designed the specific orthosis to increase radial abduction of the metacarpal of the thumb rather than immobilize the joint. This article describes the design and the clinical result of the metacarpal abduction orthosis for professional musicians with CMC joint osteoarthritis. It was hypothesized that the orthosis would not only enlarge the hand span but also relieve CMC joint pain in patients.

### Materials and Methods

Subjects consisted of 20 thumbs in 20 professional musicians with a diagnosis of osteoarthritis, pain isolated to the base of the thumb, tenderness over the CMC joint, a positive grind test, and x-ray findings of osteoarthritis. There were 19 women and 1 man, mean age 58.0 years (range, 45–82 years). There were 15 right and 5 left joints. Musical instruments played included the piano in 16 subjects, the violin in 2, and the cello in 2. All musicians were right-handed. All subjects reported difficulty in performing music requiring radial abduction of the thumb because of CMC joint pain

and joint contracture. Nine patients had been previously treated with cold packs, 3 with oral nonsteroidal anti-inflammatory drugs (NSAIDs), and one with an immobilization orthosis. Seven patients had no prior treatment.

According to the Eaton–Little classification system, radiographic assessments showed stage 2 in 12 thumbs, stage 3 in 7, and stage 4 in 1.<sup>11</sup>

The thumb abduction orthosis was custom-made of flexible polypropylene, which leaves the thumb metacarpophalangeal and wrist joints unrestricted and compresses the ulnar side of the thenar muscle to increase the radial abduction angle of the thumb metacarpal (Fig. 1). Patients could regulate the compressive pressure by tighten the band at the dorsum of the hand (Fig. 2). At the initial fitting, the trapeziometacarpal joint was checked by plain radiograph to ensure subluxation did not increase with the compressive force of the orthosis (Fig. 3).

Patients were instructed to wear the thumb abduction orthosis as long as possible, including during sleep. They could remove it to perform music and for other active hand motions such as washing dishes. No exercises for the thumb were performed. Six patients had been taking NSAIDs orally for 2.2 years on average before wearing the current orthosis. No patient took NSAIDs while wearing the orthosis.

As a clinical examination, grip strength and hand span (defined as the distance between the tip of the thumb and the tip of the little finger) were measured. Hand span was measured as a distance between the center points of the distal fingertip of the thumb and the little finger.<sup>12</sup> Grip strength was measured by the author using a grip strength meter (GRIP-D, Takei Co, Niigata, Japan). Radial abduction angle of the thumb was radiographically measured as



**Figure 3.** At the initial fitting, CMC joint radiographs were obtained to ensure metacarpal subluxation did not increase with the compressive forces of the orthosis.

the angle between the metacarpal axis of the thumb and the index finger using anteroposterior view of the hand with the thumb maximally abducted (Fig. 3). Clinical symptoms were evaluated with a 100-mm visual analog scale (VAS), ranging from 0 mm (no pain) to 100 mm (worst possible pain), and the *Quick-Disabilities of the Arm, Shoulder, and Hand (QuickDASH)* questionnaire, and hand activity for musical performance was evaluated with the Tubiana and Chamagne score (TCS), which classifies the musician's activity during performance into 6 grades: 0 = unable to play; 1 = plays several notes but stops because of pain or a lack of facility; 2 = plays short sequences without speed and with unsteady fingerings; 3 = plays easy pieces but is unable to perform more technically challenging pieces; 4 = plays almost normally but avoids difficult passages for fear of motor problems; and 5 = returns to concert performances.<sup>7,13–16</sup>

Results were compared statistically before and after the orthosis was worn, using paired *t* test for equal population variance or Welch's *t* test for unequal variance.

This study was approved by the Ethics Committee of the Tokyo Women's Medical University (approval number 4780).

## Results

The treatment period was an average of 16.7 months (range, 11–24 months). Patients wore the orthosis an average of 7.6 h/d (range, 4–14 h/d). Six patients wore it during sleep.

Mean clinical radial abduction angle of the thumb CMC joint was  $44.4^\circ \pm 8.1^\circ$  at follow-up and was significantly larger than the angle of  $38.8^\circ \pm 7.3^\circ$  before bracing ( $P = .017$ ). Grip strength increased significantly from  $15.5 \pm 2.3$  to  $19.1 \pm 2.9$  kg after bracing ( $P < .001$ ). Hand span was significantly ( $P = .002$ ) enlarged from  $186.8 \pm 13.2$  to  $197.9 \pm 6.4$  cm after bracing.

Mean VAS improved significantly from  $71.6 \pm 5.3$  to  $16.3 \pm 5.3$  mm by treatment with the abduction orthosis ( $P < .001$ ). Mean *QuickDASH* score was  $51.4 \pm 14.8$  before bracing compared with  $15.3 \pm 8.9$  ( $P < .001$ ) at follow-up. Similarly, the sports/music

additional *QuickDASH* score improved from  $61.2 \pm 21.4$  to  $15.3 \pm 8.9$  after bracing ( $P < .001$ ). The TCS for performance activity was  $4.3 \pm 0.4$  at follow-up, which was significantly improved compared with  $3.1 \pm 0.3$  before bracing ( $P < .001$ ).

Patient satisfaction with the use of the orthosis was excellent in 14 cases, good in 5, and fair in 1 whose hand span and radial abduction angle showed a limited change. Patients reported an improved hand span with increased thumb abduction angle and improved joint pain during instrumental performance and daily living activities.

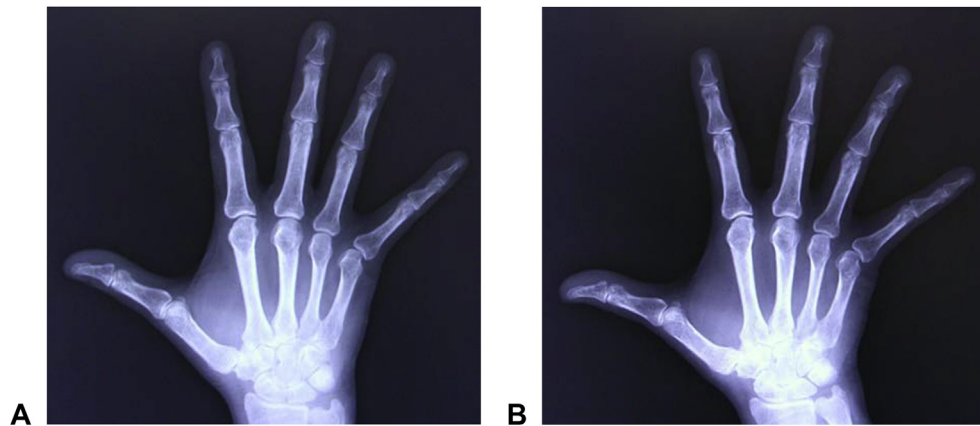
## Case

The patient was a 54-year-old female pianist with thumb pain at the CMC for 5 years. She had difficulty playing an octave or chord at the piano because of the limited abduction angle of the thumb. A metacarpal abduction orthosis was prescribed. She initially reported an uncomfortable feeling with slight pain at the CMC joint and could not wear it for more than 2 h/d. However, 4 weeks later, she felt comfortable and the wearing time increased to 6 to 8 h/d. Three months later, the orthosis was adjusted to increase the abduction angle because of improvements in the adduction contracture of the CMC joint. Four months later, joint pain improved and she stopped oral medication. Additional orthosis customization was required owing to improved adduction contracture 2 additional times, 7 and 12 months after the orthosis was initially worn. At final follow-up, the abduction angle of the thumb increased from  $39^\circ$  to  $46^\circ$  and hand span expanded from 200 to 208 mm at 12 months, which enabled the pianist patient to play an octave with no difficulty (Fig. 4A, 4B). In addition, the *QuickDASH* score improved from 90 to 13, and the VAS from 66 to 13 mm. The TCS increased from 3 to 5.

## Discussion

The thumb abduction orthosis in this study is based on a concept different from other orthoses. It focuses on pushing the first metacarpal radially and palmarly to expand the contracted joint capsule ligaments at the CMC joint.

Conservative treatments for CMC osteoarthritis have been well-described in literature, including orthotic immobilization, which has proven effective.<sup>13–17</sup> Trompetto et al<sup>18</sup> and Poole and Pellegrini<sup>19</sup> described the primary goal of stabilization of the base of the first metacarpal during pinch as preventing dorsal subluxation. Colditz<sup>20</sup> recommended preventing flexion of the first metacarpal during pinch, with thumb metacarpal and wrist joint motion unrestricted. However, Boustedt et al<sup>21</sup> pointed that using an orthosis would not provide enough pain relief in patients with a fixed CMC deformity. Their discussion focused on the concept of joint protection, which was originally designed for rheumatoid arthritis; it was expanded to osteoarthritis at the CMC joint. The abduction orthosis in this study has the much different concept of improving radial abduction of the CMC joint without restricting joint motion. The mechanism of action considers the anatomical structure and biomechanical features of the CMC joint.<sup>22,23</sup> Lee et al<sup>24</sup> described the greatest compressive loads at the first CMC joint as occurring at the volar-ulnar quadrant of the trapezium, representing a consistently affected region of wear in both normal and arthritic states. On the other hand, Kovler et al<sup>25</sup> stated that the dorsoradial trapezium region was more affected in CMC arthritis compared with other quadrants in both males and females. At a glance, these reports seem to state different, controversial points about the pathogenesis of CMC



**Figure 4.** (A) A 54-year-old female pianist with thumb pain at the CMC joint and a 39° abduction angle of the thumb and 200 mm hand span. (B) Twelve months after the thumb abduction orthosis was worn, the abduction angle of the thumb increased to 46° and the hand span expanded to 208 mm. The patient had relief of joint pain and no difficulty in playing octaves or other piano techniques.

joint osteoarthritis. However, after degenerative changes in the CMC joint surface occur, the metacarpal would be limited in internal rotation for opposition, causing a joint capsular contracture. This additional change would limit not only opposition of the thumb but also the volar-dorsal flexion and adduction-abduction movement.

The thumb abduction orthosis in this study was designed to stretch the contracted CMC joint capsule by compressing the metacarpal radially, which would change the contact area in the CMC joint surface and reduce joint pain from osteoarthritis. The compressive force produced by abduction orthosis would not affect the anterior oblique ligament, which Imaeda et al<sup>26</sup> demonstrated to be an important primary stabilizer of the CMC joint. Although the beak ligament may be stretched, this does not affect CMC joint stability, because the beak ligament is lax in both the static resting position and the final phase of opposite position.<sup>23</sup> The abduction orthosis would also stretch the adductor muscle of the thumb, which was reported by O'Brien et al<sup>8</sup> to contribute to joint contracture. The authors described a dynamic stability program included adductor muscle release performed by pinching the adductor with the opposite thumb, contracting-relaxing with stretch and manual release. Although an exercise program may be effective, abduction use of an orthosis in this study provided a more continuous stretch on the thumb adductor muscle. However, it needs additional study, particularly among patients who are not musicians. At first, the current abduction orthosis was designed for musicians with CMC joint osteoarthritis to expand the hand span for performance. However, this orthosis improved clinical symptoms at the CMC joint for daily living activities, which suggests that metacarpal abduction with an orthosis may be more widely applicable.

There were some limitations to the current study that should be addressed. The study lacked a control group of patients using a conventional orthosis or other forms of conservative treatments. Another limitation is that all material patients were only professional musicians who need a wide hand span for performance. To research the clinical effect on activities of daily living, the use of orthoses in other patient populations should be studied. The radiographic angle was not measured, because some cases lacked the accurate front CMC joint view. Finally, it is unknown how long the effects of orthoses will last. Further longitudinal study of outcomes will be important in determining the long-term effects of this orthosis on function and pain relief.

## References

- Egan MY, Brousseau L. Splinting for osteoarthritis of the carpometacarpal joint: a review of the evidence. *Am J Occup Ther.* 2007;61(1):70–78.
- Valdes K, Von Der Heyde R. An exercise program for carpometacarpal osteoarthritis based on biomechanical principles. *J Hand Ther.* 2012;25(3):251–262.
- Villafañe JH, Silva GB, Fernandez-Carnero J. Effect of thumb joint mobilization on pressure pain threshold in elderly patients with thumb carpometacarpal osteoarthritis. *J Manipulative Physiol Ther.* 2012;35(2):110–120.
- Calder KM, Galea V, Wessel J, MacDermid JC, MacIntyre NJ. Muscle activation during hand dexterity tasks in women with hand osteoarthritis and control subjects. *J Hand Ther.* 2011;24(3):207–214; quiz: 215.
- Rogers MW, Wilder FV. Exercise and hand osteoarthritis symptomatology: a controlled crossover trial. *J Hand Ther.* 2009;22(1):10–17; discussion: 19–20; quiz: 18.
- Stamm TA, Machold KP, Smolen JS, et al. Joint protection and home hand exercises improve hand function in patients with hand osteoarthritis: a randomized controlled trial. 2002;47(1):44–49.
- Glickel SZ. Clinical assessment of the thumb trapeziometacarpal joint. *Hand Clin.* 2001;17(2):185–195.
- O'Brien VH, Giveans MR. Effects of a dynamic stability approach in conservative intervention of the carpometacarpal joint of the thumb: a retrospective study. *J Hand Ther.* 2013;26(1):44–51; quiz: 52.
- Sakai N, Liu MC, Su F-C, Bishop AT, An K-N. Hand span and digital motion on the keyboard: concerns of overuse syndrome in musicians. *J Hand Surg Am.* 2006;31(5):830–835.
- Sakai N, Shimawaki S. Measurement of a number of indices of hand and movement angles in pianists with overuse disorders. *J Hand Surg Eur Vol.* 2010;35(6):494–498.
- Eaton RG, Glickel SZ. Trapeziometacarpal osteoarthritis: staging as a rationale for treatment. *Hand Clin.* 1987;3(4):455–471.
- Wagner C. Musician's hand problems: looking at individuality: a review of points of departure. *Med Probl Perform Art.* 2012;27(2):57–64.
- Ataker Y, Gudemez E, Ece SC, Canbulat N, Gulgonen A. Rehabilitation protocol after suspension arthroplasty of thumb carpometacarpal joint osteoarthritis. *J Hand Ther.* 2012;25(4):374–382; quiz: 383.
- Weiss S, LaStayo P, Mills A, Bramlet D. Prospective analysis of splinting the first carpometacarpal joint: an objective, subjective, and radiographic assessment. *J Hand Ther.* 2000;13(3):218–227.
- Gomes Carreira AC, Jones A, Natour J. Assessment of the effectiveness of a functional splint for osteoarthritis of the trapeziometacarpal joint on the dominant hand: a randomized controlled study. *J Rehabil Med.* 2010;42(5):469–474.
- Sillem H, Backman CL, Miller WC, Li LC. Comparison of two carpometacarpal stabilizing splints for individuals with thumb osteoarthritis. *J Hand Ther.* 2011;24(3):216–225; quiz: 126; discussion: 227–230.
- Swigart CR, Eaton RG, Glickel SZ, Johnson C. Splinting in the treatment of arthritis of the first carpometacarpal joint. *J Hand Surg Am.* 1999;24(1):86–91.
- Trompetto C, Avanzino L, Bove M, et al. External shock waves therapy in dystonia: preliminary results. *Eur J Neurol.* 2009;16(4):517–521.
- Poole JU, Pellegrini VD. Arthritis of the thumb basal joint complex. *J Hand Ther.* 13(2):91–107.
- Colditz JC. The biomechanics of a thumb carpometacarpal immobilization splint: design and fitting. *J Hand Ther.* 2000;13(3):228–235.

21. Boustedt C, Nordenskiöld U, Lundgren Nilsson A. Effects of a hand-joint protection programme with an addition of splinting and exercise: one year follow-up. *Clin Rheumatol*. 2009;28(7):793–799.
22. Tan AL, Grainger AJ, Tanner SF, Emery P, McGonagle D. A high-resolution magnetic resonance imaging study of distal interphalangeal joint arthropathy in psoriatic arthritis and osteoarthritis: are they the same? *Arthritis Rheum*. 2006;54(4):1328–1333.
23. Edmunds JO. Current concepts of the anatomy of the thumb trapeziometacarpal joint. *J Hand Surg Am*. 2011;36(1):170–182.
24. Lee AT, Williams A a, Lee J, Cheng R, Lindsey DP, Ladd AL. Trapezium trabecular morphology in carpometacarpal arthritis. *J Hand Surg Am*. 2013;38(2):309–315.
25. Kovler M, Lundon K, McKee N, Agur A. The human first carpometacarpal joint: osteoarthritic degeneration and 3-dimensional modeling. *J Hand Ther*. 2004;17(4):393–400.
26. Imaeda T, Cooney WP, Niebur GL, Linscheid RL, An KN. Kinematics of the trapeziometacarpal joint: a biomechanical analysis comparing tendon interposition arthroplasty and total-joint arthroplasty. *J Hand Surg Am*. 1996;21(4):544–553.