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Case Report

Effect of an orthosis on foot center of pressure translation for treatment of hallux valgus in patients with rheumatoid arthritis: A report of 17 cases

Takeshi Mochizuki [a, *], Koichiro Yano [b], Katsunori Ikari [b], Ken Okazaki [b]

[a] Department of Orthopedic Surgery, Kamagaya General Hospital, Chiba, Japan
[b] Department of Orthopedic Surgery, Tokyo Women's Medical University, Tokyo, Japan

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ABSTRACT

Objectives: We aimed to investigate the change in the center of pressure (COP) path and distribution with or without orthosis for hallux valgus (HV) in patients with rheumatoid arthritis (RA).
Methods: In total, 17 patients and 21 feet were enrolled. We measured the COP path using the COP path measurement device (F-Scan II system). The HV angle (HVA); the anteroposterior COP path length, which was measured as a percentage of the foot length (%Long); transverse width of the COP path which was measured from the most medial to the most lateral point and expressed as a percentage of maximum foot width (%Trans); and the final site of the walking locus were analyzed by comparing patients with RA with and without orthosis.
Results: Testing without and with the orthosis showed that the HVAs were 31.8° ± 9.3° and 25.2° ± 6.8° ($p < 0.001$), the %Long values were 61.1% ± 5.5% and 69.2% ± 5.9% ($p < 0.001$), and the %Trans values were 28.0% ± 9.1% and 30.1% ± 8.3% ($p = 0.108$). The final site of the walking locus for the 1st interphalangeal joint without and with orthosis were 8 feet (38.1%) and 15 feet (71.4%) ($p = 0.020$), respectively.
Conclusions: The results indicated that the orthosis for HV improved the walking path and should be considered as a therapeutic option in nonpharmacological treatment of RA.

Introduction

Foot impairment is a major adverse condition in rheumatoid arthritis (RA), and >90% patients with RA have reported foot complaints during the course of the disease.[1–3] Foot problems can lead to reduced walking distance and activity levels and impaired health-related quality of life.[4–6] Hallux valgus (HV) and lesser metatarsophalangeal (MTP) joint subluxation and dislocation are the most common findings. In patients with RA at 9 years of disease duration, the foot deformities observed are HV (65%), medial longitudinal arch flattening (42%), and claw toe (39%). In patients with RA, HV is a highly prevalent with progressive musculoskeletal foot deformity.[7] The 1st MTP joint deformity often causes lessor toe deformities and midfoot instability.[8] In patients with RA, the surgeries for HV, such as arthrodesis, resection arthroplasty, and osteotomy, have been reported to show good clinical results.[9–12] Conversely, in nonsurgical treatment for HV, education, footwear, orthoses, and anti-inflammatory drugs have been recommended and their efficacies have been reported.[13–15] In particular, footwear is routinely used. Although the efficacy differs depending on the type, footwear can improve foot pain, foot function, activity limitations, and disability.[15,16] In addition, forefoot peak pressures are reduced by footwear.[17]

We speculate that one reason for the efficacy of footwear is that it can improve the ability to walk normally. However, in previous reports, footwear and orthoses as insoles and shoes have been used for the entire foot in patients with RA.[15–17] We think that an orthosis for RA is effective if the forefoot deformity is only HV. Therefore, to confirm the effectiveness of an orthosis for HV, foot deformities other than HV, such as flatfoot, subluxation of the lesser toes, and hindfoot valgus deformity, need to be excluded.

We hypothesized that an orthosis for HV would change the center of pressure (COP) path and distribution. The aim of this

* Corresponding author. Department of Orthopedic Surgery, Kamagaya General Hospital, 929-6 Hatsutomi, Kamagaya City, Chiba, 273-0121, Japan.
E-mail address: twmutamo@gmail.com (T. Mochizuki).

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study was to investigate the effectiveness of an orthosis for HV by evaluating the change in the COP path and distribution with or without an orthosis for HV in patients with RA.

Patients and methods

This preliminary study was a case series.

Patients

In this study, we investigated the clinical course and background variables of patients with RA who fulfilled the American College of Rheumatology (ACR) classification criteria (1987) and/or the ACR/European League Against Rheumatism criteria.[18,19] A total of 17 patients (21 feet) who had HV (both HV: 4 feet, ipsilateral HV: 13 feet) were enrolled. The condition of HV was defined as an HV angle (HVA) of $\geq$21.0°.[20] The HVA was measured and defined as the angle between the longitudinal axes of the proximal phalanx of the hallux and the first metatarsal. Patients were excluded if they had undergone arthroplasty of the feet or had a deformity of the lesser toes, flatfoot, and hindfoot. Clinical data included age, sex, body weight, disease duration, anti-cyclic citrullinated peptide antibody (anti-CCP Ab) positivity, and disease activity score in 28 joints-C-reactive protein (DAS28-CRP).

We conducted this study following the principles of the Declaration of Helsinki. Informed consent was obtained from all patients. This research was approved by the Institutional Review Board of the authors' affiliated institutions (approval number: TGE01199-064).

Assessment

The orthosis for HV used in this study was commercially available, held tight by Velcro fasteners, and worn on the hallux (Fig. 1). The HVAs with or without orthosis for HV were measured on anterior–posterior X-ray images with the patient in the standing position.

A COP path measurement device, the F-Scan II system (Nitta Co. Ltd., Tokyo, Japan), was used to record walking plantar pressure and distribution. This system consists of a flexible pressure sensitive sheet to monitor planter pressure. The COP path measurement was performed by having the patient walk on a flat 10 m walking course at a comfortable speed. All patients performed the walking tasks two times with or without the orthosis for HV, and the average data of the two walking tasks were used. The final site of walking locus was categorized into three groups: 1st interphalangeal (IP) joint, 2nd to 3rd MTP joints, and 4th to 5th MTP joints. The area footprinted during walking was defined as the anteroposterior COP path length, which was measured as a percentage of the foot length (%Long), and as the transverse width of the COP path, which was measured from the most medial to the most lateral point and expressed as a percentage of the maximum foot width (%Trans).[21] The peak planter pressure without and with the orthosis was measured at the forefoot area. The forefoot area was divided into 1st toe, medial third (medial 1/3), center third (center 1/3), and lateral third (lateral 1/3) of the forefoot width.

The endpoints of the study were as follows: change in HVA on radiographs, change in anteroposterior length and width on COP path, change in final site on COP path, and change in peak planter pressure of the forefoot.

Statistical analysis

Statistical analysis was performed to compare the measurements of the RA patients with and without orthosis. HVA, %Long, and %Trans were analyzed by paired t-test. The final site of walking locus was assessed by Fisher's exact test. The peak planter pressure was compared between without and with orthosis using the Wilcoxon signed-rank test. Statistical significance was established at a p value of $\leq$0.05. All analyses were performed by using the R Statistical Package, version 3.3.2 (http://www.r-project.org/).

Results

Patients with the following characteristics were enrolled: age (mean ± SD) 67.5 ± 10.1 years; female, 94.1%; body weight, 51.3 ± 7.7 kg; disease duration, 11.9 ± 11.2 years; anti-CCP Ab positivity, 76.5%; and DAS28-CRP, 2.34 ± 1.24.

The HVA without orthosis was 31.8° ± 9.3°. By using the orthosis, the HVA was significantly decreased to 25.2° ± 6.8° ($p < 0.001$; Fig. 2). The HVA improved in all patients.

The %Long values without and with orthosis were 61.1% ± 5.5%

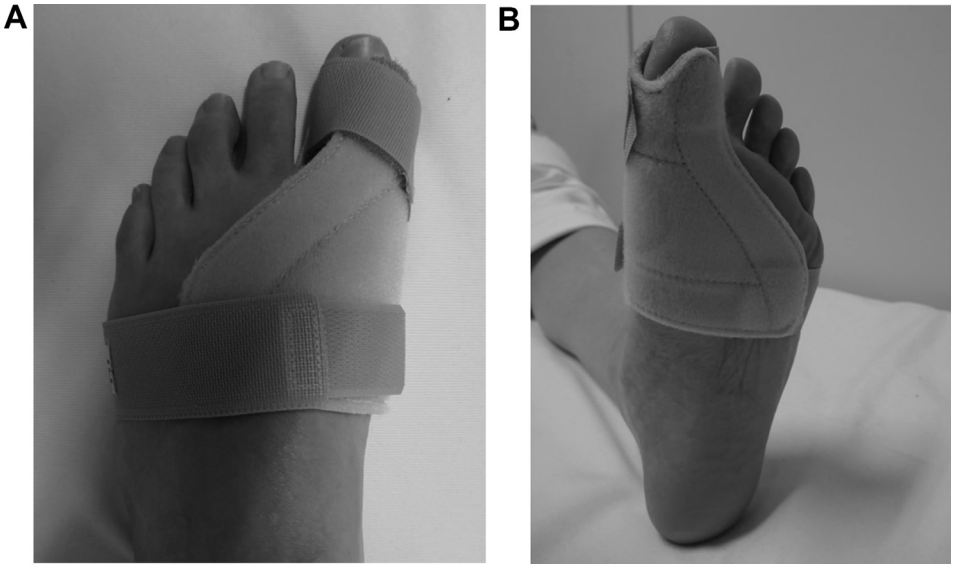

Fig. 1. Orthosis for hallux valgus: superior view (a) and inferior view (b).

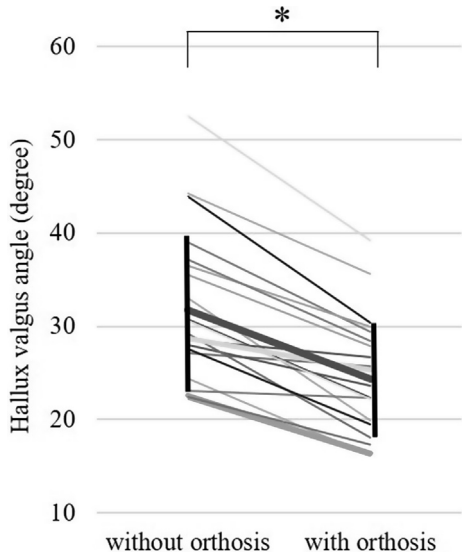

Fig. 2. The hallux valgus angles without and with orthosis
Bold line, change in the mean hallux valgus angles; vertical line, standard deviation; *p < 0.001.

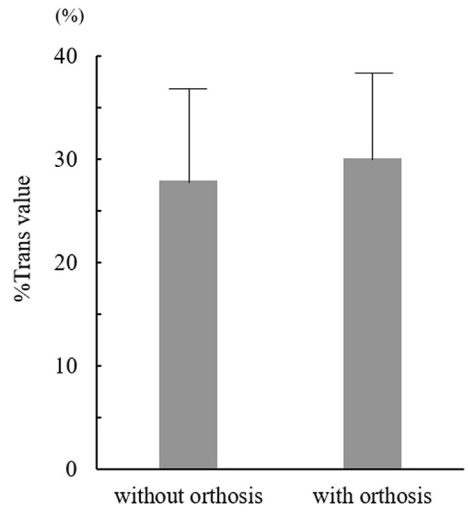

Fig. 4. The %Trans values of the patients without and with orthosis.

and 69.2% ± 5.9%, respectively (Fig. 3). There was a significant difference in the comparison of the %Long without and with orthosis ($p < 0.001$). The %Trans values without and with orthosis were 28.0% ± 9.1% and 30.1 ± 8.3%, respectively (Fig. 4). There was no significant difference in the %Trans, comparison without and with orthosis ($p = 0.108$).

For HV without the orthosis, the feet were assigned the final site of walking locus as follows: 1st IP joint, 8 feet (38.1%); 2nd to 3rd MTP joint, 11 feet (52.4%); 4th to 5th MTP joint, 2 feet (9.5%). For HV with the orthosis, the feet were assigned the final site of walking locus as follows: 1st IP joint, 15 feet (71.4%); 2nd to 3rd MTP joint, 5 feet (23.8%); 4th to 5th MTP joint, 1 foot (4.8%). A significant difference was observed in the 1st IP joint in final site of the walking locus between the HV without and with orthosis ($p = 0.020$).

The peak planter pressures at 1st toe were 514.8 ± 359.9 kPa and 754.1 ± 515.8 kPa without and with the orthosis, respectively ($p = 0.006$). The peak planter pressures at medial 1/3 were 592.9 ± 231.3 kPa and 504.7 ± 250.9 kPa without and with the orthosis, respectively ($p = 0.166$). The peak planter pressures at central 1/3 were 683.5 ± 486.4 kPa and 474.6 ± 254.0 kPa without and with the orthosis, respectively ($p = 0.012$). The peak planter pressures at lateral 1/3 were 470.4 ± 299.1 kPa and 371.7 ± 240.3 kPa without and with the orthosis, respectively ($p = 0.031$).

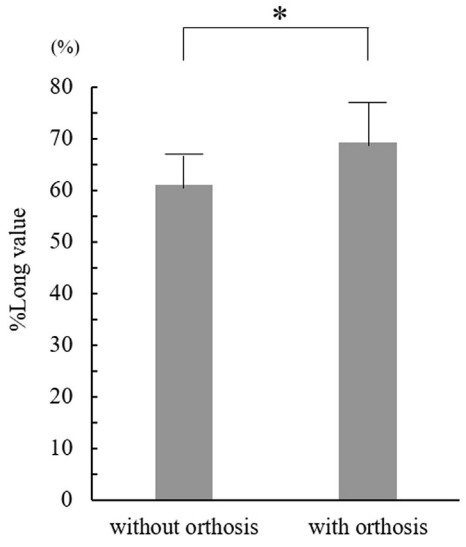

Fig. 3. The %Long values of the patients without and with orthosis, *p < 0.001.

Discussion

This study investigated the effect of an orthosis on HV as seen from foot COP translation in patients with RA. The HVA was significantly decreased by using the orthosis. Therefore, we believe that %Long and the final site of walking locus were improved. On the other hand, using an orthosis, the mean change in HVA was 6.6°. Although the HVA improved in all patients, there were cases where HVA ≥21.0° remained. We think this might be a limitation of the orthosis for HVA.

In RA, walking speed, cadence, and stride length have been found to be decreased, and peak plantar pressure at the forefoot have been found to be increased.[22] In previous reports, various types of footwear or foot soles have been used as orthoses in patients with RA. In a comparison of supportive shoes worn alone, supportive shoes worn with soft orthoses, and supportive shoes worn with semirigid orthoses, the supportive shoes worn with semirigid orthoses were found to have had a significant effect on metatarsalgia.[23] In a comparison of running footwear and orthopedic footwear, running footwear was found to be more effective on the basis of forefoot pressure–time integrals.[17] The efficacy of orthosis intervention has been shown for rheumatoid feet. Regarding HV in RA, an orthosis with posting of the heel and forefoot was previously found to suppress progression of HV deformity.[24] We agree that these orthoses are efficacious for patients with HV and flatfoot or splayfoot. However, in daily practice, we observe some patients who only have HV as foot deformity. In RA, HV is presumably due to synovitis of the 1st MTP joint and subsequent medial subluxation of the 1st metatarsal base.[25] Moreover, HV restricts 1st MTP extension during gait. This limitation of 1st MTP joint motion leads to tight plantar aponeurosis via the proximal phalanx.[26,27] In the present study, we used a commercially available off-the-shelf orthosis to be worn on the hallux. We found that this orthosis decreased the HVA and speculated that it improved the motion of the 1st MTP joint and decreased tension plantar aponeurosis. Therefore, we believe that

the increased %Long improved step length. Moreover, we found that the final site of walking locus of the patients with HV tended to show an increased hallux. The typical COP path begins at the heel, goes through the center somewhat outside, and passes through the hallux.[28] Moreover, the planter pressure of the 1st toe was significantly increased, whereas those of central and lateral points were significantly decreased in this study. The orthosis used in this study led to a normal walking path.

This study had several limitations. First, this study was small sample size and a trial study. Therefore, different results may be obtained if the number of cases increased and long-term observed. Moreover, we did not obtain functional assessments of the foot. Second, in this study, the foot COP translation was measured over a short walking distance. However, to reduce this effect, we measured the foot COP translation in the middle of the 10 m walking course.

In conclusion, foot orthoses are important devices in the non-pharmacological and nonsurgical treatment of RA. This study is the first study to evaluate the efficacy of a commercially available off-the-shelf orthosis to be worn on the hallux for patients with HV. The results of this study indicated that an orthosis for HV improved walking path and was easy to wear and safe. An orthosis for HV should be considered as a therapeutic option in non-pharmacological treatment in patients with RA.

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Declaration of competing interest

T. Mochizuki received honorariums for lectures from AbbVie, Astellas, Bristol-Myers, Chugai, Daiichi Sankyo, Eisai, Eli Lilly, Janssen, Mochida, Pfizer, Tanabe-Mitsubishi, and Takeda. K. Yano received honorariums for lectures from AbbVie, Astellas, Ayumi, Bristol-Meyers, Eisai, Hisamitsu, Mochida, and Takeda. K. Ikari received honorariums for lectures from AbbVie, Astellas, Bristol-Myers, Chugai, Eisai, Eli Lilly, Janssen, Takeda, Tanabe-Mitsubishi, and UCB. The other authors declare that they have no conflicts of interest.

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