

Original Article

A comparison of the hallux valgus angle, range of motion, and patient satisfaction after use of dynamic and static orthoses



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ABSTRACT

Background: Conservative treatment is recommended for mild and moderate hallux valgus. The treatment may include two different types of orthoses: a dynamic orthosis and a static orthosis. The aim of this study was to compare the hallux valgus angle, hallux valgus range of motion, and patient satisfaction after the use of a dynamic and a static orthosis for the treatment of hallux valgus.

Methods: Twenty-four participants contributed to this cross-over study. Participants were randomly allocated to orthotic treatments at the start. The hallux valgus angle and range of motion were measured using a goniometer. Pain, signs and symptoms, function in activities of daily living (ADL), function in sport and recreation, and foot and ankle-related quality of life (QOL) were measured using the Foot and Ankle Outcome Score (FAOS) questionnaire. The participants then switched to using the other orthosis. A one-way repeated measure ANOVA was conducted to compare the measured variables in subjects at 4 conditions before and after of using each orthosis.

Results: There was a significant difference in the hallux valgus angle ($p = 0.001$). The Bonferroni test indicated that both static and dynamic orthoses significantly decrease the angle of hallux valgus, respectively before static, after static (mean difference = -2.67 , $p = 0.001$) and before dynamic, after dynamic conditions (mean difference = -2.13 , $p = 0.02$). There was also a significant difference in subjects range of motion by using a dynamic orthosis in before dynamic, after dynamic conditions (mean difference = 9.77 , $p = 0.01$). There was no significant difference in total FAOS score within the conditions ($p = 0.067$).

Conclusion: The use of both static and dynamic orthoses for 1 month can reduce the hallux valgus angle up to $2-3^\circ$. To achieve better results, it is suggested to wear orthoses for longer time. The dynamic orthosis also increases the passive range of motion of the first metatarsophalangeal joint and it seems to be effective during walking.

1. Introduction

Hallux valgus is one of the most common foot disorders of biomechanical origin [1]. In hallux valgus, the first metatarsophalangeal joint is progressively subluxed due to lateral deviation of the first phalanx and medial deviation of the first metatarsal [1]. The prevalence of hallux valgus has been reported to be 0.9% among all age groups and to increase from 12 to 56% with aging [2,3]. Lateral deviation of the hallux leads to metatarsal rotation and valgus torque on the metatarsophalangeal joint, which pushes the hallux away from its articular surface. Reduced joint congruence and loss of articular cartilage results in a decreased range of motion and pain in the metatarsophalangeal joint [1,4–6].

Hallux valgus causes many problems, including psychological issues and impaired quality of life (QOL) [7]. Preventing general disability

and halting the progression of structural changes are important for the management of hallux valgus. Previous nonsurgical studies demonstrated the effectiveness of static orthoses worn at night in the treatment and prevention of hallux valgus progression [8,9]. Recent studies have proposed the use of a dynamic orthosis that applies a corrective force during walking. Dynamic orthoses with free joint motion that do not prevent first metatarsophalangeal movement are thought to be more effective than static orthoses in the management of hallux valgus [8]. Unfortunately, few studies have compared the effectiveness and ease of use of different types of orthoses. The aim of this study was to compare the hallux valgus angle, hallux valgus range of motion, and patient satisfaction after the use of a dynamic and a static orthosis for the treatment of hallux valgus.

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2. Material and methods

2.1. Participants

This study adopted a cross-over design and included 24 participants (females, $n = 12$; males, $n = 12$). The participants were among the students of the School of Rehabilitation Sciences, Iran University of Medical Sciences and were selected using the single non probability sampling method. The inclusion criteria were the presence of mild to moderate hallux valgus, at least 10% motion limitation of total normal range of motion in sagittal plane ($110^\circ: 34^\circ$ Dorsi + 76° Plantar) in the first metatarsophalangeal joint [10], a pain score more than 2 based on a visual analog scale, aged 19–33 [11], sufficient education to complete a questionnaire independently, and a commitment to wear standard shoes (e.g., wide toe box and 2–3 cm heel height) during the study. The exclusion criteria were history of hallux valgus treatment; foot surgery; various diseases, such as rheumatoid arthritis, diabetes, gout, and leprosy; neurological diseases; and dislocations or fractures of the metatarsophalangeal joints.

The research was approved by the Human Research Ethics Committee of Iran University of Medical Sciences. After informing the participants about the objectives of the study and test conditions, they were asked to voluntarily sign an approved consent form.

2.2. Data collection and measurements

To assess the severity of the deformity, the Manchester scale (Fig. 1) was employed. This scale indicates mild, moderate, and severe level of deformity [12,13]. Demographic data, range of motion of the joint and hallux valgus angle were recorded [14]. The hallux valgus angle (Fig. 2) and passive range of motion of the first metatarsophalangeal joint (Fig. 3) were measured using a goniometer [14–16]. For angle measurement in the bipedal weight-bearing position, the goniometers' pivot was placed on the middle point of the head of the first metatarsal bone. The fixed arm of the goniometer was then placed on the longitudinal line of the first metatarsal bone, while the movable arm was placed on the longitudinal line of the great toe. For range of motion measurement, in non-weight-bearing position, one arm set on the first metatarsal bone and the other arm set on the hallux and the ankle was maintained in neutral position. The range of motion of the hallux from maximum dorsiflexion to plantar flexion was recorded. Each measurement was repeated three times, and the average was considered [17].

Patient satisfaction was measured by the Foot and Ankle Outcome Score (FAOS), which is a reliable and valid questionnaire for foot evaluations [18–21]. The FAOS instrument contains 42 questions, which are divided into five sections. Each item includes five levels: none, mild, moderate, severe, and extreme, with a score of 0–4 for each item. All the scores were summed and calculated using the formula developed by the originators of the scale. In this calculation, a score of 0 indicates a severe problem, and a score of 100 represents no problem. Each participant completed the questionnaire before and after using each of the orthosis. After recording demographic and baseline information, the individuals were randomized to receive one of the two types of orthosis: a dynamic or a static orthosis. The static orthosis (hallux valgus splint, Teb-sanat, ISO 13485, Iran, Tehran) (Fig. 4) consisted of a bar and a single strap, which fixed the orthosis on the medial side of the foot. The dynamic orthosis (Hallufix, Sharifi, Iran, Tehran) (Fig. 5) was made of firm plastic and contained straps to fix it on the foot. The orthosis has a free joint on the metatarsophalangeal prominence to permit motion of this joint.

After providing adequate explanations regarding the use of the orthosis, it was fitted on the participant's feet. For each participant, the shape of the bar was changed to fit the anatomical shape of the first ray. At the end of 1 month, there was a 1 week wash-out period [22]. Each participant was given a self-assessment questionnaire at the beginning of each orthosis. The questionnaire included questions about the

number of hours of wearing the orthosis and the type of shoe worn. Any participant who had used the orthosis for less than 6 h or who had worn inappropriate footwear (e.g., narrow toe box, high heeled) during the day was excluded. At this stage, the orthotic type was changed, and the individuals who had worn the dynamic orthosis were switched to the static orthosis and vice versa. Before and after the second treatment period, the measurements of the hallux valgus angle and range of motion were repeated.

2.3. Statistical analysis

The data were analyzed using the statistical SPSS package version 20 (SPSS Inc, Chicago, IL, USA). A one-way repeated measure ANOVA was conducted to compare the measured variables in subjects at 4 conditions; before static orthosis, after static orthosis, before dynamic orthosis and after dynamic orthosis. The Levene's test for homogeneity of variances was checked. The number was greater than 0.5 and the assumption of homogeneity was not violated. The significance level for all tests was set at 0.05.

3. Results

The demographic data on base of sex and in total were presented in Table 1. The mean and standard deviations of the angle, the range of motion, and the patient satisfaction are demonstrated in Table 2. There was a significant difference in the hallux valgus angle between conditions, Wilks Lambda = 0.187, $F(3, 21) = 30.499$, $p = 0.001$, partial eta squared = 0.813. Post-hoc comparison using the Bonferroni test indicated that the mean angle of hallux valgus after using both orthoses were significantly decreased, respectively, before and after static orthoses (mean difference = -2.67 , $p = 0.001$), before and after dynamic orthoses (mean difference = -2.13 , $p = 0.02$), and before static and before dynamic orthoses (mean difference = -2.37 , $p = 0.002$) (Table 3). The post-hoc test comparison between after static and before dynamic orthoses conditions indicated that the angle of hallux valgus significantly increased during the wash-out period (mean difference = 2.42 , $p = 0.02$). There was also a significant difference in subjects range of motion in the conditions, Wilks Lambda = 0.419, $F(3, 21) = 9.70$, $p = 0.01$, partial eta squared = 0.581 (Table 3). A post-hoc comparison using the Bonferroni test indicated that the mean range of motion after using dynamic orthoses were significantly increased in before and after dynamic orthoses conditions (mean difference = 9.77 , $p = 0.01$) (Table 2). There was no significant difference in total FAOS score within conditions, Wilks Lambda = 0.610, $F(3, 21) = 4.476$, $p = 0.067$, partial eta squared = 0.390 (Table 3).

4. Discussion

The aim of this study was to evaluate the angle, the range of motion, and the patient satisfaction following the application of dynamic and static orthoses in 24 patients with hallux valgus. Previous studies suggested that orthoses and stretching could correct deviation of the joint [9,23,24]. Similar studies that compared the effects of static and dynamic orthoses (i.e., an insole with a toe separator) concluded that the application of a corrective force during walking via the use of the dynamic orthosis was more effective than the static orthosis in reducing pain related to hallux valgus and the hallux valgus angle [25–27]. Therefore, the attention was derived to the point that if an orthosis permitted free range of motion of the metatarsophalangeal joint, in addition to keeping corrective alignment of this joint, it can be worn while walking [8]. In later research, Mathew et al. showed that a dynamic orthosis reduced contracture of first metatarsophalangeal joint and improved the alignment of the hallux through low torque and prolonged stretching, with the latter creating a strong corrective force [24]. In the present study, the deformity of the hallux valgus angle was reduced to a similar level after the use of both the dynamic and static

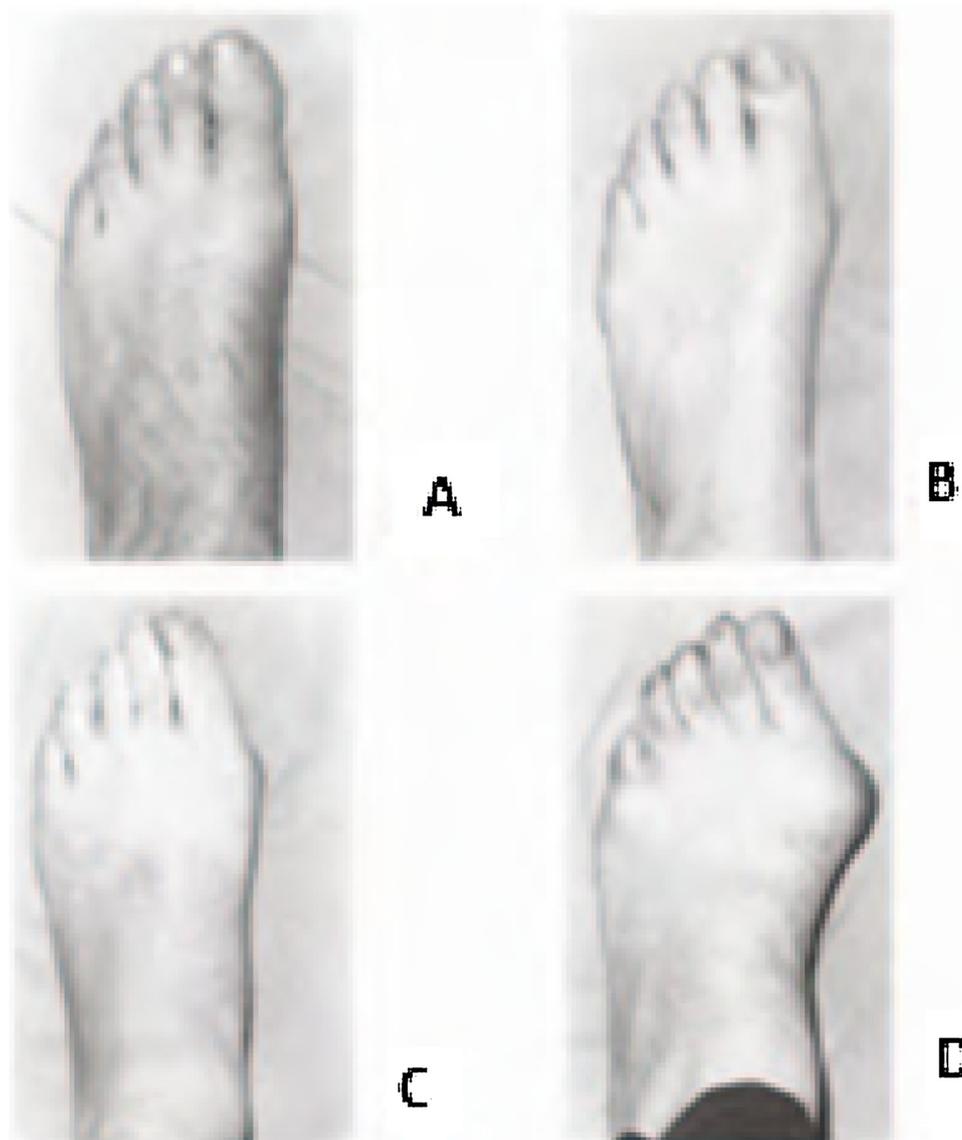


Fig. 1. Manchester scale. (A) Normal (B) Mild (C) Moderate (D) Severe.

orthoses for 1 month. Although, the angle was decreased 2–3° after using orthoses, the Cohen's effect size of the angle was 0.8 which is considered clinically acceptable. Note that these changes have been obtained just after one month of using orthoses and for better achievement, at least 6-month application is required. The persistence of the effect of orthosis is another point which could be assessed by evaluating changes during the wash-out period. Based on results, the comparison of angle between before static and before dynamic conditions did not show any significant differences. This reflecting the fact that the angular changes are related to the time when orthosis is worn, so these changes were returned to first state by doffing the orthosis. It is important to mention that, due to the flexible muscle structure in this age group, it is necessary to use an orthosis for a longer time to stabilize the effect of orthosis [11].

The result of comparing range of motion between conditions demonstrated that only the dynamic orthosis increased the passive range of motion of the first metatarsophalangeal joint. This finding may be attributed to the freedom of joint motion in the dynamic orthosis, which does not limit the active range of motion of the hallux. The reduction of joint congruence leads to arthritis, which decreases the range of motion and causes pain [1,4,6,28]. In studies that compared the effects of exercise therapy and an orthosis on the hallux valgus

deformity, both methods significantly decreased the hallux valgus angle and pain [9,23]. Thus, preserving the joint mobility and preventing joint stiffness seems to have a beneficial effect on the treatment of hallux valgus.

The findings of the FAOS questionnaire showed that there were no differences in satisfaction before and after using both orthoses. The patient's scores on the subclasses (i.e., signs and symptoms, pain, ADL, function in sport and recreation, and foot and ankle-related quality of life) of the FAOS improved after wearing the orthotic devices after 1 month but the changes were not significant. Tang et al. used an 11-point numeric rating scale to assess the pain and walking ability of individuals with painful hallux valgus who wore an insole with a toe separator and observed a significant improvement immediately and 3 months after using this dynamic orthotic device [25]. The insole with a toe separator can correct the alignment of the first metatarsophalangeal joint during gait and prevent load deformation. Also, Tehraninasr et al. used a visual analogue scale to assess pain in hallux valgus patients. Pain decreased after using an insole with a toe separator, but not after wearing a night splint [26]. Arge et al. assessed pain in women with hallux valgus deformity and used the Foot Function Index to investigate the effect of a home-based exercise for 2 months. In their study, the severity of pain, decreased significantly, indicating that exercise



Fig. 2. Hallux valgus angle measurement.



Fig. 4. Night orthosis.

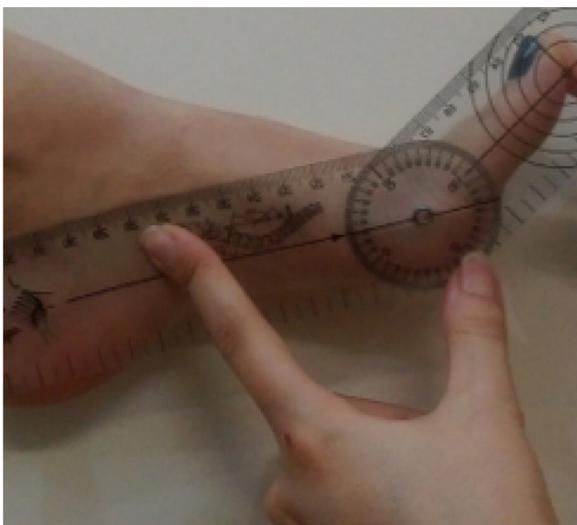


Fig. 3. Measurement of range of motion by goniometer.



Fig. 5. Dynamic orthosis.

(mobility) decreased stiffness and led to a realignment of the joint, thereby decreasing pain [17]. According to these studies it was assumed that, a dynamic orthosis which applies a corrective force during walking and maintains the correct alignment of the metatarsophalangeal joint may reduce contracture and hallux valgus pain more than static orthosis. But the efficacy of none of orthoses in FAOS subscales was taken through one month using. Sheree et al. concluded that passive structural factors, including the hallux valgus angle, did not seem

Table 1
Subjects characteristics were categorized by gender.

	Female			Male			Total		
	N	M	SD	N	M	SD	N	M	SD
Age	12	22.75	1.36	12	22.83	1.58	24	22.79	1.44
Height	12	1.65	0.04	12	1.79	0.03	24	1.72	0.08
Weight	12	60.71	6.60	12	73.25	12.20	24	66.97	11.56
BMI	12	22.29	2.64	12	22.71	3.55	24	22.50	3.07

to show a significant correlation with the severity of hallux valgus pain [29]. According to this idea, when evaluating painful hallux valgus, the characteristics of the patient, including the patient's general health and

Table 2
Mean and standard deviation of variables in subjects (N = 24).

	Static orthosis				Dynamic orthosis				
	Before		After		Before		After		
	M	SD	M	SD	M	SD	M	SD	
Angle	18.21	3.41	15.54	3.74	17.96	3.75	15.83	3.94	
Range of motion	120.04	18.22	121.39	19.72	117.50	19.82	127.27	17.97	
FAOS Total Score	77.63	12.52	82.04	10.39	77.60	14.49	80.78	11.20	
FAOS subscales	Symptoms	71.09	15.50	77.59	10.23	75.52	11.64	77.08	9.69
	Pain	85.28	12.24	87.49	12.29	81.61	17.41	85.89	14.50
	ADL	87.18	12.23	92.91	10.31	85.20	17.22	90	14.21
	Function	78.47	18.70	84.72	15.47	80.55	19.91	85.06	16.84
	Quality of life	66.14	16.68	67.44	16.48	65.10	16.78	65.88	15.63

Table 3
The mean differences (p-value) of variables from the pair wise comparison between important conditions.

	Angle	Range of motion	FAOS score
Before static/after static	-2.67 (0.001)	1.35 (0.99)	4.40 (0.20)
Before dynamic/after dynamic	-2.13 (0.001)	9.77 (0.01)	3.19 (0.09)
Before static/before dynamic	-0.25 (0.999)	-2.54 (0.99)	0.04(0.99)
Before static/after dynamic	-2.38 (0.002)	7.23 (0.79)	3.15 (0.09)
After static/before dynamic	2.42 (0.001)	-3.89 (0.95)	-4.44 (0.17)

physical activity level, should be considered rather than satisfaction.

In general, participants have more satisfaction with dynamic orthosis than static one due to the ease of use and fitting and better appearance. However, a disadvantage of the dynamic orthosis was that multiple orthoses were required for each patient due to the risk of the orthosis breaking while walking. The participants also complained that both orthoses twisted on their feet. This was a particular problem with the static orthosis, where twisting occurred on the second toe.

The limitations of this study include a lack of X-ray assessments of the hallux valgus angle. The latter was not performed due to the high risks associated with radiation at the short time of the study. In addition, the orthotic intervention was relatively short (1 month), and a longer-term follow-up was not conducted. This study was conducted on young age as they have the intact bone structure and their joint not affecting by degenerative disease [11]. Also, this age group were a convenient sample. So, the external validity of this study is limited to the young population and may not be generalized to juvenile and elderly hallux valgus. Another limitation of this study is the measurement error by goniometer that was not considered. Though, few studies had investigated the accuracy of goniometer with methods such as radiography, and its repeatability and reliability is confirmed [30,31].

5. Conclusion

The use of both static and dynamic orthoses for 1 month can reduce the hallux valgus angle up to 2–3°. To achieve better results, it is suggested to wear orthoses for longer time. The dynamic orthosis also increases the passive range of motion of the first metatarsophalangeal joint and it seems to be effective during daily walking.

Conflict of interest declaration

We have no conflict of interest to declare.

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