# Plantar Pressure Changes of Patients with Heel Valgus in Rheumatoid Arthritis

## *Topuk Valguslu Romatoid Artritli Hastaların Taban Basınç Değişiklikleri*

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**Abstract**

**Objective:** Long-standing rheumatoid arthritis (RA) causes foot problems in approximately 90% of the patients. In this study, we aimed to document the plantar pressure distribution changes in RA patients with heel valgus and to compare results in those without valgus.

**Material and Methods:** This study was performed on 22 feet of 11 RA patients with bilateral heel valgus (Group 1) and 28 feet of 14 RA patients without heel valgus deformity (Group 2). Both static and dynamic pedobarographic evaluations were performed in both groups to determine the plantar pressure values and to make comparisons between the groups. Erosion scores of both groups were also compared.

**Results:** In dynamic pedobarographic evaluation, only the plantar contact area was found to be greater in Group 1 than Group 2. However, in the static evaluation, forefoot pressure percentage, plantar contact area and forefoot plantar contact area values were higher in Group 1 than Group 2. In radiographic evaluation, erosion scores were again found to be higher in Group 1.

**Conclusion:** According to results of the pedobarographic evaluation in this study, heel valgus deformity in the RA patients led to increases in plantar contact area and forefoot pressure percentages. *(Turk J Rheumatol 2009; 24: 67-71)*

**Key words:** Rheumatoid arthritis, heel valgus, plantar pressure, pedobarography

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**Özet**

**Amaç:** Uzun süreli romatoid artrit, hastaların yaklaşık % 90'ında ayak problemlerine yol açar. Bu çalışmada topuk valguslu hastaları topuk valgussuz hastalar ile karşılaştırarak taban basınç dağılımındaki değişiklikleri saptamayı amaçladık.

**Yöntem ve Gereçler:** Çalışmada topuk valguslu 11 romatoid artritli hastanın 22 ayağı (grup 1) ile topuk valgussuz 14 romatoid artritli hastanın 28 ayağı (grup 2) değerlendirildi. Her iki grubun statik ve dinamik pedobarografik değerlendirmesi yapılarak taban basınçları saptandı ve bu veriler üzerinden her iki grup arasında karşılaştırma yapıldı. Her iki grubun erozyon skorları karşılaştırıldı.

**Bulgular:** Dinamik pedobarografik değerlendirmede sadece taban temas alanı grup 1 de grup 2 den yüksek bulundu. Statik değerlendirmede, ön ayak basınç yüzdesi, taban temas alanı ve ön ayak taban temas alanı grup 1 de grup 2 ye göre yüksek bulundu. Radyolojik değerlendirmede erosyon skorları yine grup 1 de yüksek bulundu.

**Sonuç:** Romatoid artritli hastalarda topuk valgus deformitesi pedobarografik değerlendirmede taban temas alanı ve ön ayak basınç yüzdesinde artışlara neden olur.
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**Anahtar sözcükler:** Romatoid artrit, topuk valgusu, taban basıncı, pedobarografi

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## Introduction

Long-standing rheumatoid arthritis (RA) causes foot complaints in approximately 90% of the patients. The arthritis starts with foot involvement in 17% of the patients (1, 2). Inflammation of joints and soft tissues, even when vigorously treated, can severely disrupt foot structure by causing joint damage and structural deformities (3). Although forefoot involvement is more common in the earlier period of the disease, the hindfoot problems become the major element of dysfunction as the duration of the disease prolongs (4, 5). Valgus deformity develops over the course of time in RA patients as a result of a sort of adaptation behavior. As a result, forefoot deformities are usually seen in the early period of RA, while hindfoot deformities develop in the later course of the disease. This may be understood as the reflection of the earlier painful forefoot pathology to the hindfoot in the later period (4).

The most frequent hindfoot deformity in RA patients is heel valgus (6). Despite the lack of data on the etiopathogenesis of valgus deformity, its effect on functional status is well known (6). Various hypotheses exist about the occurrence of heel valgus in RA patients. The first of these relates to malformations in cartilage and bone structure. The laxity in the joint capsule and ligaments of the subtalar and midtarsal joints is usually caused by inflammation and swelling. Afterwards, tenosynovitis

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occurs in the posterior tibial tendon, causing pain during walking and valgus deformity in the foot. The second probable etiopathogenetic factor is the equinus contracture of the ankle. Muscle wasting and pain occur subsequent to the valgus deformity in the tibiotalar joint, which leads to a decrease in varus pressure in the hindfoot. Consequently, the foot tends to accommodate the body weight on the metatarsal bones during walking. The weight of the lower extremity forces the foot into excessive external rotation and the foot progresses to valgus deformity in an effort to adapt itself to this position (4,6-8). Supporting this hypothesis, we observed during our static pressure evaluation that forefoot pressure percentage and forefoot contact area increased in RA patients with heel valgus when compared with patients without valgus deformity.

Changes in foot structure may be associated with impaired foot function during weight-bearing. Furthermore, impaired foot function, expressed as alterations in gait and plantar pressure (9, 10), may relate to pain and disability during daily activities.

Rheumatord Arthritis has been associated with a range of foot deformities and distinctive patterns of plantar pressure distribution (11, 12). The detection of plantar pressure distribution of the foot by pedobarography can reveal useful information for clinicians (7). Plantar pressure measurements are performed to evaluate the situation of the foot in every stage of foot pathologies leading to deformity. This procedure is a pre-evaluation tool before modification of a convenient orthosis or shoe. It is better to perform pedobarography together with clinical and radiographic evaluation, and it should be utilized in the periodical visits of RA patients. Clinicians aim to recover impaired plantar pressure because of deformities (13). In this study, we aimed to document the plantar pressure distribution changes in RA patients with heel valgus and to compare results in patients without deformity. To the best of our knowledge, the literature lacks data about pedobarographic plantar pressure alterations in RA patients with heel valgus.

## Materials and Methods

This study was performed on 22 feet of 11 RA patients with bilateral non-fixed heel valgus deformity (Group 1) and 28 feet of 14 RA patients without heel valgus deformity (Group 2) in our outpatient clinic. The RA diagnosis was based on the American Rheumatism Association (ARA) criteria (14). Patients with moderate or severe disease activity according to Disease Activity Score (DAS)-28 (DAS-28<2.6) were excluded from the study because of the probable serious plantar pressure variations due to pain in the active period. Other exclusion criteria included: 1) lower extremity operation such as prothesis operations in hip, knee, ankle or foot, 2) leg length discrepancies, 3) problems of cooperation, including eye, ear or cognitive disorders, 4) vascular insufficiency, and 5) walking aids. Demographic and disease-related characteristics of the patients such as age, body mass index (BMI) and disease duration were assessed and noted.

Heel valgus deformity was diagnosed by measurement of the ankle between a vertical line down from the middle of the popliteal fossa and a line between the ankle and the heel. The measured angle by a goniometer indicated the severity of heel valgus tilt (15). Angles of more than 20° were regarded as a calcaneal valgus (Figure 1).

Pedobarographic assessment was performed by a Mini-EMED pedobarography device. This system measures plantar pressure on a platform in a static and dynamic manner. The dimensions of the pressure measurement platform of the device are 650x290x25 mm. This platform consists of three sensors in each cm². The sampling rate is 16 frames / sec, storage range is 20 frames, pressure range is 2-127 N/cm², resolution is 1 N / cm², accuracy related to foot is ±5%, temperature range is between 15°-40°, and the magnitude of power supply is 220/110 V. The Mini-EMED platform was mounted into a 5X2 m walkway and the floor was at the same level. The platform was placed 4m from the starting position of the walkway to minimize the effect of acceleration or deceleration. The mini-EMED is a commercially available electronic system for recording and evaluating the distribution of pressures on the plantar aspect of the foot.

During static measurements, the patients were asked questions to distract them from focusing on the plantar side of the foot and to prevent a postural tendency which may cause overpressure on one side of the foot. The patients were asked to focus on a constant point on the wall located 3 meters away. While standing on the platform, the average width of stride should be 8 cm. The data on the monitor screen was fixed and recorded when the weight on a single foot was observed to be equal to 50% of the body weight.

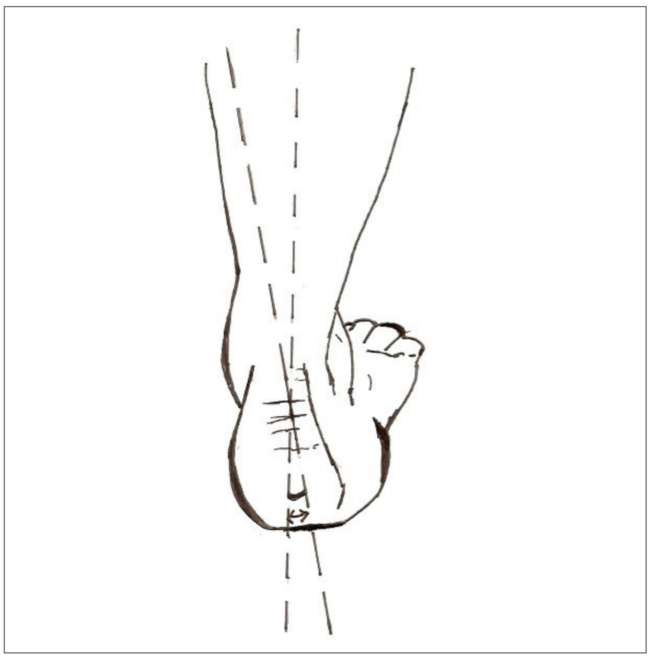

**Figure 1. Calcaneal valgus**

As the body balance was provided strictly, one measurement was found sufficient. The evaluation was performed separately for each foot. The dominant foot was the right in all the patients, and the right foot was evaluated first followed by the left in each patient. Static evaluation was performed first to reduce patient stress.

For dynamic measurement, the patients were asked to walk continuously along an area 30 meters in length for a few minutes before arrival to the wooden walking platform 5 meters in length. They were instructed to place the foot on the platform during their normal walking rhythm. The normal walking rhythm was taken as the standard for each patient, as it is known that the walking speed could maximally affect the pressure values as much as 7% (16). The patients were asked to retry in case of a fixed stride and wrong foot position on the platform. The walking period was performed separately for each foot. Ten acceptable trials were collected (17). Five walks for each foot (10 walks for each subject) were recorded and printed. The average of three values eliminating the maximal and minimal values was used in the analysis. Each print consisted of a time peak-force curve for six regions of interest on the foot. The regions of interest, which were analyzed automatically by the system software, were the heel, midfoot, lateral, central and medial forefoot, and the toes.

Foot radiographs were taken in anteroposterior and lateral views in a standard manner with the feet under full weight-bearing. Radiologic evaluation was performed by an experienced radiologist. The modified Larsen (ML) method was used to evaluate erosion severity (18). In the ML method, pathologic changes of joints are graded between 0 and 5 as: 1: erosions of less than 1 mm or joint space narrowing, 2: one or more erosions greater than 1 mm, 3: erosions of significant size, 4: severe erosions, and 5: mutilating changes. The first interphalangeal (IP) and the second, third, fourth, and fifth metatarsophalangeal (MTP) joints of both feet were evaluated, and the scores of all the joints were added (maximum score 25). The first IP joint was preferred over the MTP joint as the latter is a characteristic site for gout and osteoarthritis involvement.

Patients in both groups were compared in terms of the static and dynamic pedobarographic variables obtained. Erosion scores were also compared. Test of normality (Kolmogorov-Smirnov and Shapiro-Wilk) was performed for the parameters in each group. Plantar contact area (dynamic), total contact area (static), forefoot contact area (static), and hindfoot contact area (static) showed normal distribution, so the Student's t test was performed to make between-group comparisons in case of a significant difference. None of the remaining parameters showed normal distribution, so Mann-Whitney U test was performed to make between-group comparisons in case of a significant difference.

## Results

There was no statistically significant difference in terms of age, disease duration and BMI between the groups ($p>0.05$). The demographic characteristics of patients in both groups are presented in Table 1. The mean heel valgus angle ± SD was found to be 21.82±2.46 (min:20°, max:25°) in Group 1. The current deformities of the patients are shown in Table 2.

**Table 1.** The demographic properties of the patients

| | Group 1 (Heel valgus) | Group 2 (Control) | p |
|---|---|---|---|
| Age (year) | 60.00±11.76 | 54.36±7.40 | 0.10 |
| Sex (F/M) | 7/4 | 11/3 | |
| BMI (kg/m²) | 25.03±3.21 | 26.52±3.05 | 0.14 |
| Disease duration (year) | 9.81±8.44 | 9.18±9.97 | 0.34 |

F/M: Female/Male, BMI: body mass index

**Table 2.** Current foot deformities in two groups

| | Hallux Valgus n | Hammer toe n | Clap toe n |
|---|---|---|---|
| Group 1 (Heel Valgus) | 8/22 | 10/22 | 4/22 |
| Group 2 (Control) | 11/28 | 9/28 | 3/28 |

In dynamic pedobarographic evaluation, plantar contact area was found to be higher in Group 1 than Group 2 ($p<0.05$) (Table 3).

In static pedobarographic evaluation, no significant difference was observed in terms of forefoot and hindfoot peak pressure values between Group 1 and Group 2 ($p>0.05$). Forefoot pressure percent values were significantly different between Group 1 and 2, being higher in Group 1 ($p<0.05$). The patients in Group 1 had significantly higher forefoot contact area percentage ($p<0.05$). Total contact area was significantly higher in Group 1 than Group 2 ($p<0.05$) (Table 4).

Forefoot erosion scores in the radiographic evaluation were observed to be higher in RA patients with heel valgus deformity when compared with patients without heel valgus ($p<0.05$) (Table 5).

## Discussion

Our findings revealed changes in static pedobarographic evaluation rather than dynamic evaluation in RA patients with heel valgus when compared to those without heel valgus. The expected pressure changes in RA patients seem to accelerate with the addition of heel valgus to the clinical picture. In addition to the comparability of our groups in terms of demographic characteristics, the mean disease duration of patients in both groups was approximately 10 years, and this parameter was not significantly different between groups.

In the early and painful period, RA patients also tend to increase the forefoot contact area in order to diminish pressure pain on metatarsal heads (19). In the long-term, this tendency to increase continues with a time-dependent adaptive period. Taking into consideration that erosions occur during the first two years of the disease peri-

**Table 3.** Comparison of dynamic pedobarographic values between group 1 and 2

| | Group 1 (Heel valgus) Mean±SD | Group 2 (Control) Mean±SD | p |
|---|---|---|---|
| Peak phalanx pressure (N/cm$^2$) | 19.91±6.41 | 18.93±4.11 | 0.90 |
| Medial forefoot peak pressure (N/cm$^2$) | 10.59±5.13 | 10.57±3.70 | 0.55 |
| Middle forefoot peak pressure (N/cm$^2$) | 23.27±11.60 | 27.32±13.35 | 0.24 |
| Lateral forefoot peak pressure (N/cm$^2$) | 31.18±18.05 | 27.29±6.91 | 0.67 |
| Midfoot peak pressure (N/cm$^2$) | 29.36±27.12 | 23.96±9.35 | 0.65 |
| Hindfoot peak pressure (N/cm$^2$) | 38.55±28.61 | 35.14±11.68 | 0.30 |
| Plantar contact area (cm$^2$) | 131.27±11.99 | 123.11±13.42 | 0.02* |

SD: Standard deviation

**Table 4.** Comparison of static pedobarographic values between group 1 and 2

| | Group 1 (Heel valgus) Mean± SD | Group 2 (Control) Mean±SD | p |
|---|---|---|---|
| Forefoot peak pressure (N/cm$^2$) | 7.86±4.65 | 7.69±2.92 | 0.34 |
| Hindfoot peak pressure (N/cm$^2$) | 11.04±5.72 | 9.64±2.84 | 0.70 |
| Forefoot pressure (%) | 49.23±7.46 | 41.93±6.91 | 0.001* |
| Hindfoot pressure (%) | 50.77±7.46 | 58.07±6.91 | 0.001* |
| Total contact area (cm$^2$) | 97.18±7.58 | 80.18±14.49 | 0.001* |

SD: Standard deviation

**Table 5.** Comparison of erosion scores between group 1 and 2

| | Group 1 (Heel valgus) Mean± SD | Group 2 (Control) Mean± SD | p |
|---|---|---|---|
| Erosion 1$^{st}$ metatars | 0.64±1.00 | 0.14±0.36 | 0.04* |
| Erosion 2$^{nd}$ metatars | 1.00±1.15 | 0.25±0.58 | 0.01* |
| Erosion 3$^{rd}$ metatars | 1.13±1.21 | 0.28±0.60 | 0.01* |
| Erosion 4$^{th}$ metatars | 1.13±1.35 | 0.43±0.70 | 0.04* |
| Erosion 5$^{th}$ metatars | 1.10±1.51 | 0.53±0.99 | 0.22 |
| Erosion total score | 5.00±5.41 | 1.63±2.42 | 0.01* |

SD: Standard deviation

od leading to significant pain, it would be logical to think that progression of valgus deformity in a foot with erosions is an adaptive process. This is very important because in a former study, disease duration and related erosive changes were found to affect the pedobarographic plantar pressure values, which could potentially complicate our efforts to determine the specific effect of heel valgus deformity (20). The reflection of this change in our patient group can be seen in pressure values. Radiographic evaluation also revealed higher erosion scores in this group. Although forefoot maximal pressure values were not different between the groups in dynamic evaluation, higher values of plantar contact area and forefoot contact area obtained in the static evaluation confirmed the presence of heel valgus.

Only plantar contact area as a dynamic plantar pressure parameter in RA patients with valgus deformity was different when compared to the patients without valgus deformity. It is difficult to comment on this point; however, pain in RA interrupts ambulation and normal gait more than structural changes, and this fact can help to explain the absence of a difference. Our patients were in the chronic period of RA, relatively without inflammation and consequent pain. Mechanical variations in the late phase of the disease might lead to plantar contact area increases.

The first limitation of this study is its cross-sectional design, which makes it difficult to discuss some points definitively. If the patients had been evaluated longitudinally, we could have followed the deformity-plantar pressure-erosion relation more clearly. The second limitation of the study is the limited number of participants, although prior studies faced the same problem.

Our findings support the hypothetical mechanisms that lead to heel valgus. The increased forefoot pressure area percentage and the increased forefoot contact area seem to be the results of the efforts of the patient to decrease pain by increasing the plantar area. The decrease in the hindfoot area leads to increase in pressure. The expected pressure change in RA patients seems to be accelerated with the addition of heel valgus to the clinical picture. The use of plantar supports and shoe modifications that provide balanced distribution of plantar pressure from the beginning of the disease can help to block the development of heel valgus and related knee and hip deformities.

During the acute period in RA, stress on the rheumatoid joints should be reduced in addition to pharmacological treatment. To minimize the probability of deformities, the forefoot and longitudinal arcus should be supported with suitable pads. Otherwise, important plantar pressure alterations can develop as a consequence of deformities.

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