The relationship of disease duration to foot function, pain and disability in rheumatoid arthritis patients with foot complaints

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Abstract

Objective

To assess the relationship between disease duration and foot function (expressed as pressure and gait parameters), foot pain and disability, in patients with foot complaints secondary to rheumatoid arthritis (RA).

Methods

Sixty-two patients with RA-related foot complaints were included. Disease duration was defined as the time since RA was diagnosed. A pressure platform was used to measure both pressure parameters (i.e. pressure-time integrals and peak pressures in the forefoot) and gait parameters (i.e. total loading time and loading time in different foot regions). In addition, measurements of foot pain, disability (i.e. walking time and self reported disability), forefoot joint damage and disease activity were obtained. Data were analysed using partial correlations (Spearman), correcting for age.

Results

Disease duration was significantly correlated with the maximum pressure-time integral (PTI) measured under the forefoot ($r = 0.330$, $p = 0.01$). Disease duration was also significantly correlated with gait parameters, i.e. total loading time ($r = 0.265$, $p = 0.04$), duration of heel loading and duration of toe loading ($r = 0.326$, $p = 0.01$ and $r = -0.288$, $p = 0.03$ respectively), and walking time ($r = 0.297$, $p = 0.02$). Disease duration did not correlate with self-reported foot pain or disability.

Conclusion

In patients with RA-related foot complaints, longer disease duration is associated with impaired foot function and reduced walking speed. These findings are interpreted as an alteration in pressure distribution and gait pattern during the course of disease, with a shift from a heel-to-toe roll-over process to a more shuffling gait.

Key words

Foot, rheumatoid arthritis, disease duration, plantar pressure, gait, pain, disability.

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Received on May 4, 2006; accepted in revised form on December 5, 2006.

Introduction

More than 90% of rheumatoid arthritis (RA) patients complain of foot or ankle problems at some time during their disease. A general upward trend in the percentage of RA patients who experience foot complaints as disease duration progresses has been found (1). Also, a worsening of the foot statics due to deformities and an increased frequency of flat foot and first ray deformity during disease has been reported (2, 3). In addition, joint damage in the forefeet, as well as joint damage in the hands, has been found to increase with disease duration (4-6).

Changes in foot structure are supposed to lead to alterations in foot function during weight-bearing. In an earlier investigation by our research group, forefoot joint damage was associated with increased pressure under the forefoot (7). Furthermore, increased forefoot pressure was related to foot pain (7, 8), and alterations in gait parameters were related to disability (7, 9, 10). Therefore, foot function, expressed as pressure and gait parameters, appears to be of clinical relevance in studying the rheumatoid foot.

Foot function impairments, foot pain and foot-related disability are hypothesized to deteriorate as the disease progresses. In previous studies, all using a cross-sectional design, increased forefoot pressure (11, 12) and alterations in gait characteristics (9, 13) in RA-patients were found. In these studies, patients with established RA were compared to healthy subjects. No studies have been conducted on the course of foot function in a group of RA- patients with foot complaints in different phases of the disease. In the present study we investigated relations between disease duration and foot function, foot pain and foot-related disability. In the absence of prospective studies, information on the relationship with disease duration offers valuable insights into the course of foot function, foot pain and foot-related disability in RA.

The aims of the present study were to assess the relationships between disease duration and foot function (expressed as pressure and gait parameters), foot pain, and disability in patients with foot complaints secondary to rheumatoid arthritis (RA).

Patients and methods

Patient selection

Sixty-two patients of an outpatient clinic for rehabilitation and rheumatology (Jan van Breemen Institute) in The Netherlands served as the study population. The following inclusion criteria were used in the study: 1) rheumatoid arthritis (RA) diagnosed by a rheumatologist (according to ACR criteria) (14); 2) referred to a podiatrist or a rehabilitation physician for RA-related foot complaints, and 3) older than 18 years of age. Exclusion criteria were: 1) inability to walk independently; (2) inability to complete questionnaires (because of language or cognitive problems); and 3) ambulation problems due to non RA-related causes. The medical ethics committee of the Slotervaart Hospital in Amsterdam approved this study and written informed consent was obtained from each subject.

Disease duration measures

Disease duration was defined as the time in years since RA was diagnosed by a rheumatologist. Disease duration was obtained by searching the case history of the patient.

Foot function measures

Foot function was expressed as pressure and gait parameters in this study. To obtain these parameters, measurements were performed using an EMED®-nt (Novel Electronics, Novel gmbh, Munich, Germany) pressure platform (4 sensors per cm^2, sample frequency 50 Hz). The platform was mounted in the middle of a walkway of 5 meters. A two-step method of collecting the measurements was used and data from both feet were collected (15). All patients started with their right foot. Three correct measurements per foot were recorded. Pressure and gait data were analysed with Novel-Ortho® and Novel-Win® software. A division mask (Novel-mask®) divided the foot in 10 anatomically referenced regions: heel, midfoot, first to fifth metatarsophalangeal joint (MTP), hallux, second toe and other toes.

Pressure parameters consisted of peak pressures and pressure-time integrals, calculated for each foot region. Peak pressure (PP) was determined by the highest pressure measured by a single sensor in a region. The pressure-time integral (PTI) of a region was defined as the integral of pressure over time measured in the single sensor within that region showing the peak pressure. Pressure data from the forefoot were used in further analyses, as this region is known to play an important role in foot pathology in RA patients. The maximum PP and maximum PTI of the forefoot, and the PP and PTI per MTP were calculated. Gait parameters collected were: total loading time (in msec) and loading time per foot region (expressed as a percentage of total loading time).

Measures of disability in daily activities

Disability was assessed using the physical functioning (PF) subscales of the Foot Function Index (FFI) and the WOMAC, and a 10-meter walking test.

The FFI measures pain and mobility limitation as an impact of foot problems. The scale consists of 23 items divided into 3 subscales: pain (9 items), physical functioning (9 items) and limitation (5 items) (16). The items are rated on a 5 point-scale, which is a modification by Kuyvenhoven *et al*. (the original FFI uses VAS scales) (17). To calculate the subscale-scores and the total score, the item scores are summed up, divided by the maximum possible sum of the item scores and then multiplied by 100. The scores range from 0 to 100; the higher the score, the more pain, disability and limitation, respectively.

The WOMAC (Western Ontario and McMasters Universities Osteoarthritis Index) was designed to measure pain, joint stiffness and physical functioning as the impact of osteoarthritis in the hips and knees (18, 19). For the present study, the impact of arthritis in the hips, knees, ankles and feet was measured. The WOMAC consists of 24 items divided into 3 subscales: pain, joint stiffness and physical functioning. The scores range from 0 to 100 (as a percentage of the maximal total score); the higher the score, the more pain, stiffness and disability, respectively.

For the 10-meter walking test, the patient was instructed to walk for a distance of 10 meters at a normal, comfortable walking speed. The time taken to walk this distance was recorded.

Foot pain measures

Pain in the feet during activities was measured by the pain subscale of the Foot Function Index.

Additional measures

Joint damage was expressed according to the Sharp/van der Heijde method (20). A trained rheumatologist scored the radiographs of the feet. The 10 metatarsophalangeal and 2 interphalangeal joints of the big toes were scored for erosions and joint space narrowing. The total score is the summation of erosions and joint space narrowing in all joints of both feet, ranging from 0 to 168.

Disease activity was expressed as a composite index consisting of a swollen and painful joint count of 44 joints, the erythrocyte sedimentation rate (ESR in mm/hour) and a visual analogue scale (VAS) for general health (21). A trained clinical research assistant performed the measurements and calculated the disease activity score (DAS-44). The DAS-44 (instead of the DAS-28) was used, as the ankle and foot joints are included in this score.

Other data recorded were sex, age, body mass index (BMI; weight/length^2), medication and the location of foot complaints.

Data and statistical analyses

Pressure and gait data for what was, according to the patient, the more severely affected foot (n = 62) were used for further analysis, as the most affected foot is believed to be the primary factor in the foot pain and disability reported by patients.

All variables were ranked since the disease duration and joint damage, FFI and WOMAC scores were not normally distributed. Partial correlations (Spearman) were used to establish the relationships between disease duration and the other variables, corrected for age. Age is hypothesized to be a confounder in the relationship between disease duration and data for foot function, foot pain and disability. Two-sided testing was used and results were considered statistically significant if p-values were < 0.05. All analyses were performed using SPSS (version 12.0).

Results

Descriptive data

The characteristics of the patients are shown in Table I. Sixty-two patients were analysed; 47 women and 15 men, with a mean age of 55.7 years and a median disease duration of 8.0 years. The majority of the patients (89%) reported forefoot pain as their main foot complaint. The mean disease activity score was 2.4 and the median physical functioning (PF) scores of the FFI and WOMAC were 19.1% and 17.3% of the maximum score, respectively.

Relationships between disease duration and foot function

Table II shows the correlations between disease duration and foot function, corrected for age.

Disease duration was significantly correlated with the maximum pressure-time integral (PTI) measured under the forefoot ($r = 0.330$, $p = 0.01$). Further analyses of the metatarsophalangeal joints (MTP) showed disease duration to correlate significantly with the PTI of MTP1, MTP3 and MTP4 ($r = 0.325$; $p = 0.01$, $r = 0.324$; $p = 0.01$ and $r = 0.314$; $p = 0.01$, respectively). In addition, disease duration was significantly correlated with peak pressure (PP) under MTP1 ($r = 0.270$; $p = 0.04$).

Disease duration was significantly correlated with the following gait parameters: total loading time ($r = 0.265$, $p = 0.04$), loading time of the heel (as a percentage of total loading time) ($r = 0.326$, $p = 0.01$), and loading time of the hallux, second toe and other toes ($r = -0.288$, $p = 0.03$; $r = -0.347$, $p = 0.01$; $r = -0.288$, $p = 0.03$, respectively) (correlations for the toes are not shown in the table).

Relationships between disease duration and foot pain

Disease duration was not significantly

Table I. Characteristics of the patients (n = 62).

Age (yrs.)[a]	55.7 (13.1)
Sex (M/F)	15/47
BMI (kg/m^2)[a]	26.4 (3.7)
Disease duration (yrs.)[b]	8.0 (3.0, 12.0)
Medication (% of patients)	
NSAIDs	50%
DMARDs	84%
Biologicals	13%
DAS-44[a]	2.4 (1.0)
Sharp/van der Heijde score feet[b]	8.0 (1.5, 24.5)
Forefoot complaints (% of patients)	89%
Pressure parameters	
PP-forefoot (N/cm^2)[a]	63.2 (25.0)
PTI-forefoot (N/cm^2)*s[a]	21.4 (8.7)
Gait parameters	
Total loading time (msec)[a]	852.1 (153.6)
Heel loading (% total loading time)[a]	59.7 (9.1)
Foot pain (FFI-pain subscale)[b]	28.6 (18.2, 41.7)
Disability	
FFI-PF[b]	19.1 (8.0, 45.1)
WOMAC-PF[b]	17.3 (5.7, 46.7)
Walking test (sec)[a]	8.3 (1.8)

Data are means (SD)[a], medians (IQR)[b], percentages or numerical data.

correlated with foot pain (FFI-subscale) ($p > 0.05$; Table II).

Relationships between disease duration and foot-related disability

A significant correlation between disease duration and walking time was found ($r = 0.297$, $p = 0.02$). No significant correlations between disease duration and self-reported physical functioning, as measured with the FFI and WOMAC, were identified ($p > 0.05$; Table II).

Secondary analyses

A significant correlation between disease duration and forefoot joint damage, expressed as the Sharp/van der Heijde score, was identified ($r = 0.461$, $p = 0.00$; Table II). No significant correlation between disease duration and disease activity (DAS-44) was found ($p > 0.05$).

Discussion

The aim of the present study was to assess the relationship between disease duration and foot function, pain and disability in patients with RA-related foot complaints.

The results of this study showed a worsening in foot function, expressed as pressure and gait parameters, with disease duration. For the forefoot, pressure parameter values increased: disease duration correlated significantly with the maximum pressure-time integral (PTI) under the forefoot. Further analyses of the metatarsophalangeal joints (MTPs) showed that disease duration was related to the PTI under the first, third and fourth MTP and the peak pressure under the first MTP. In addition, gait parameters altered: the total loading time was prolonged, the loading time of the heel (as a percentage of the total loading time, the so-called heel lift) increased, and the loading time of the toes decreased.

These results suggest an alteration in the roll-over process during the stance phase of the foot with disease duration. A prolonged stance phase, a delayed heel lift and shorter plantar loading of the toes indicates a shift from a heel-to-toe roll-over process to a more shuffling gait. The delay in heel lift is thought to be associated with forefoot impairment in RA and may result from the patients' effort to compensate for forefoot pain by reducing forefoot pressure (9). Despite this compensation effort, the pressure-time integral under the forefoot increased with disease duration in our study group. This may be the result of a decrease in loading time of the toes, due to forefoot and toe deformities. When the toes do not contribute adequately to support bodyweight during the late stance phase of gait, the load is almost exclusively transferred to the MTPs (22). The alteration in the roll-over process, with a prolonged loading time and a delayed heel lift, has been reported in studies comparing RA patients with healthy subjects (9, 13). Impaired foot function related to disease duration in a group of RA patients has not been described before. The present study indicates that the alteration in the roll-over process is indeed related to disease duration.

Although, in this study, the correlation coefficients found were weak, they reached statistical significance using a limited number of patients, indicating the existence of true relationships. Differences in disease progression between patients might be an explanation

Table II. Correlation coefficients for disease duration and pressure parameters, gait parameters, foot pain, disability, forefoot joint damage and disease activity, corrected for age.

	Disease duration	p-value
Pressure parameters		
PTI-forefoot	0.330	0.01
PP-forefoot	0.150	0.25
Gait parameters		
Total loading time	0.265	0.04
Heel loading	0.326	0.01
Foot pain (FFI-subscale)	0.042	0.75
Disability		
FFI-PF	0.123	0.35
WOMAC-PF	0.109	0.41
Walking test	0.297	0.02
Forefoot joint damage	0.461	0.00
DAS-44	0.225	0.08

for these weak correlations. Not only the duration of disease, but also the severity of the disease activity over time and the extent of structural changes of the foot and lower limb are supposed to affect foot function.

After the correction for age, significant correlations between disease duration and pressure and gait parameters were still found. This is an important finding as elderly people may walk more slowly and with an altered gait pattern: thus, higher age could be an alternative explanation for our findings. Nevertheless, because the correlations remained significant after correction for age, it appears that disease-related factors do contribute to the worsening of foot function, irrespective of age-related changes.

The results of the present study confirm the value of pressure and gait parameters in the clinical understanding of RA-related foot complaints. Pressure under the forefoot is related to pain (7, 9), while pain (7, 23) and altered gait (7, 9, 10) are related to disability. The present study contributes to our understanding of alterations in pressure and gait parameters during the course of the disease. Assessment of pressure and gait parameters is a valuable component in the comprehensive evaluation of foot complaints in RA.

Self-reported foot pain and foot-related disability did not increase with the disease duration in our study group. One explanation for the lack of a relationship between disease duration and foot-related disability might be the difference between observed and self-reported disability. While walking time increased significantly with disease duration, patients reported only a small, non-significant decrease in physical functioning as measured using the FFI and WOMAC. This might be due to the adaptation of patients during the course of the disease; their reference frame regarding the performance and frequency of physical activities might adapt itself to their limitations.

In a review article by Pollard *et al.* (2000) (24), a slow increase in disability and pain scores was reported with disease duration. After an initial decrease in pain and disability scores in early disease (due to the immediate benefits of medical treatment), a subsequent gradual rise in pain and disability scores was shown. This J-shape curve of pain and disability was not found in our study group. On the one hand, our study group might not have been large enough to reveal such correlations, and on the other hand our study group was selected based on the presence of foot complaints and therefore levels of pain may be present regardless of disease duration.

A limitation of this study is the heterogeneity of patients with regard to their medical treatment history. Changes in medication protocols may influence the impact of foot complaints in RA. Furthermore, in the present study, a cross-sectional design to examine a longitudinal phenomenon was used, and, therefore, no causalities can be implied. However, although the long-term consequences of RA are preferably assessed in longer duration follow-up studies, cross-sectional studies, including patients with a broad range of disease durations, seem to provide fairly reliable estimates of the course of health outcomes in RA (25). As so little is known about foot function, foot pain and foot-related disability during disease, this study represents a valuable step in studying foot complaints over the course of RA.

In conclusion, in patients with RA-related foot complaints, longer disease duration is associated with impaired foot function and reduced walking speed. These findings are interpreted as an alteration in pressure distribution and gait pattern during the course of disease, with a shift from a heel-to-toe roll-over process to a more shuffled gait.

Acknowledgements

We gratefully acknowledge the podiatrists and rehabilitation physicians of the Jan van Breemen Institute for referring patients to the study, and the clinical research assistants for performing the measurements of the disease activity score.

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