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Assessment of foot impairment in rheumatoid arthritis patients by dynamic pedobarography

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Abstract

Objectives: Impaired foot function may jeopardize the mobility of patients with rheumatoid arthritis (RA). However, there are still no guidelines concerning the adequate early treatment of painful rheumatoid feet which do not yet require surgery. An assessment method for RA feet appears necessary in order to detect foot problems before functional limitations develop. Therefore, the aim of the present study was to evaluate the use of pedobarographic measurements for detecting changes in plantar loading characteristics and their relationship to foot pain in patients with RA.

Methods: One hundred and twelve patients with RA (55.0 ± 11.0 years of age) were divided into three groups according to their Health Assessment Questionnaire (HAQ) Score and compared to a control group of 20 healthy adults (CG). Thirty-six patients with good physical capacity belonged to group 1 (RA1; HAQ-score: 0–1.0), 38 patients with moderate capacity to group 2 (RA2; score: 1.1–2.0) and 38 patients with low capacity to group 3 (RA3; score: 2.1–3.0). Each patient's foot pain was clinically assessed. Pedobarography was used to analyze foot loading parameters while walking barefoot.

Results: In the forefoot, average pressures under the lateral forefoot were higher in RA1 patients than in RA2 patients and controls ($p < 0.05$) despite an inconspicuous clinical examination of the foot in RA1 patients. RA1 patients also demonstrated higher plantar pressures than RA2 under the second metatarsal head ($p < 0.05$). In contrast, no significant differences in maximum force could be demonstrated between patient groups. Furthermore, in RA3 patients with lower physical capacity, foot pain was increased as compared to RA1 and RA2 patients.

Conclusion: In RA patients, pedobarographic patterns show specific changes which characterize the level of functional capacity. In patients with foot involvement, pedobarographic measurements can be useful during the earlier stages of the disease, when clinical examination does not yet indicate the need for more aggressive treatment or orthopedic interventions.

Keywords: Rheumatoid arthritis; Pedobarography; Foot mechanics

1. Introduction

Foot and ankle problems are common among the general population over the age of 55, second only to knee problems [1]. The implications may be even more severe for patients suffering from rheumatoid arthritis (RA), which is one of the most frequent reasons of limited functional capacity [2] and affects about 0.3–1.5% of the population world wide [3]. Rheumatoid feet are often affected by pain and multiple deformities and may therefore be the primary cause for limitations in function and quality of life [4]. Nevertheless, treatment decisions and prognostic assessments are predominantly based on clinical evaluation of the rheumatoid hand as can be seen in the recently recommended DAS-28 score that is a reduced version of the previously recommended DAS-45 at the expense of disregarding the feet.

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However, early treatment of the rheumatoid foot is strongly recommended before RA patients suffer significant pain during walking and foot deformities [5]. Surgical intervention is often necessary in fixed deformities whereas flexible deformities may require treatment with orthoses and medication to prevent deterioration [6]. Elevated plantar pressures are thought to cause mechanical damage to the rheumatoid foot [7–10]. Patients with foot problems are often treated with orthotic insoles with the aim to ensure normal plantar loading and to prevent excessive local pressures. This treatment is often controlled by in-shoe pedobarography for the assessment of individual foot loading characteristics. However, there are no guidelines concerning adequate early treatment of painful rheumatoid feet which do not yet require surgery [11]. An assessment method for RA feet is required in order to detect foot problems before functional limitations develop [12]. Barefoot pedography is commonly used as it is easy to use and is harmless to patients. Using this technique, various aspects of dynamic foot loading characteristics in RA patients were previously investigated [13–16]. Foot loading abnormalities and deformities can be detected by measuring foot loading during barefoot walking [17]. Nevertheless, pedobarography is not yet established in the regular control of RA patients. Rheumatoid foot problems are usually evaluated by clinical scores, pain assessment and radiography in order to assess the individual degree of impairment and joint destruction. However, it should be noted that radiography exposes the patient to potentially harmful radiation. This is particularly concerning in chronically ill patients requiring regular screening. Furthermore, radiography is a static procedure and provides no information about dynamic foot function [18,19]. Finally, radiographic images do not reveal deformities sufficiently in the early stages of the disease [5,20]. Walking pain assessment is also not recommended in the assessment of foot impairment because plantar sensitivity can be significantly reduced in RA patients [21].

The aim of the present study was to evaluate the use of pedobarographic measurements for detecting changes in plantar loading characteristics. Pedobarographic gait patterns and foot pain were recorded in RA patients of different functional capacity in order to objectively assess foot function in comparison with a control group. We focused on the rheumatoid forefoot because deformities are predominantly located in this region with a percentage of 90–97% of all adult RA patients [5,22].

2. Materials and methods

One hundred and twelve patients with RA who met the 1987 American College of Rheumatology criteria for RA were examined. Patients were asked to participate in the study during or after visiting the University Hospital Münster or the St. Josef-Stift Sendenhorst (Nordwestdeutsches Rheumazentrum). All patients signed a written informed consent form which had been approved by the local ethics committee. The average age of the patients was 55.0 ± 11.0 years (range 31–79). Further inclusion criteria were: (1) independent walking ability; (2) bilateral foot pain during walking; (3) no orthopaedic impairment in the lower extremity; (4) no systemic disease with relevant influence on walking ability and pain assessment; (5) no previous foot and ankle surgery. Furthermore, 20 subjects with an average age of 53.2 ± 12.3 years (range 31–68) served as a control group (CG). These subjects were free of: (1) foot problems, (2) other orthopaedic impairments and (3) systemic disease that was assumed to affect gait patterns.

Patients were divided into three groups according to their Health Assessment Questionnaire score (HAQ-score). The HAQ-score is one of the most widely used scores in the clinical assessment of patients with rheumatoid arthritis and is used for the assessment of patients' functional disability. It indicates the functional capacity in relation to different activities such as dressing, getting up, walking, taking care of hygiene, reaching, gripping and further activities. A low HAQ-score represents a better physical capacity, while a high HAQ-score indicates a more pronounced functional impairment. Reliability and validity of the German version of the HAQ has previously been confirmed [23]. Thirty-six patients were included in group RA1 (HAQ-score: 0–1), 38 patients in group RA2 (score: 1–2), and 38 patients in group RA3 (score: 2–3). The limits for the HAQ-scores were chosen to represent equally sized groups with low, intermediate, and high functional impairment since an average score of 0 stands for unlimited ability to perform specific activities and a score of 3 stands for inability to perform these activities. Furthermore, the foot function index (FFI) was used to assess foot specific impairments [24]. Disease activity was examined by using the rheumatoid arthritis disease activity index (RADAI) [25].

Walking pain of only the right foot of every patient was evaluated by using multiple-item scales that represent the degree of pain in chronic diseases [26]. We did not include both feet to avoid false-positive statistical findings [27]. All patients were clinically examined with a focus on foot tenderness. Pain during palpation of five forefoot areas and the subtalar joint was noted as being present or not in order to detect local signs of inflammation. The subtalar joint was examined because its function is thought to affect forefoot mechanics [28].

For pedobarographic measurement patients were asked to walk across a capacitive pressure distribution platform (EMED ST4, Novel GmbH Munich, Germany) embedded in the floor. This platform consists of 2736 sensors with a spatial resolution of 4 sensors/cm^2 and measures the dynamic foot loading with a frequency of 50 Hz. Patients were asked to walk with normal steps at self-selected speed. The patients took at least three steps before and after the platform to ensure recording of a step in full gait. Measurements were repeated until five steps of the right foot were recorded. For a detailed analysis of plantar foot loading all foot prints were subdivided into 10 regions by using the Novel 'PRC'-mask (Fig. 1): medial (MH) and lateral heel (LH), medial (MM) and lateral midfoot (LM), first metatarsal (M1), second metatarsal (M2), lateral metatarsals (M345), hallux (H), second toe (T2) and lateral toes (T345). Masking was performed per default and was modified when the automatic process did not result in an appropriate subdivision in case of severe deformity. As mentioned before, we focused on the latter six foot regions in order to concentrate on forefoot mechanics. Maximum force and average pressures were calculated for these regions. Average pressures were determined because this parameter was reported to show a good correlation with walking pain in RA patients [29]. The average pressure was calculated by dividing the pressure–time integral by contact time for every investigated foot area. The contact time of