

MRI in Clinically Asymptomatic Neuropathic Leprosy Feet: a Baseline Study¹

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Leprosy is an infectious disease caused by *Mycobacterium leprae* that affects 2–10 million patients worldwide. It preferably invades skin and peripheral nerves.

In leprosy the neuropathic foot is one of the major contributors to morbidity due to peripheral nerve damage. Repeated injury subsequently may lead to considerable osseous and articular destruction secondary to sensory loss. The skeletal abnormalities may be severe and are evident in 20%–70% of hospitalized patients (¹⁵). The neuro-osteoarthropathy (Charcot deformity) in leprosy is comparable to that in diabetes and may lead to tarsal disintegration with osteolysis, fragmentation and progressive bone resorption. In extreme cases, dissolution of the midfoot results in separation of the forefoot and the hind foot, changing all biomechanics and weight bearing areas.

Diagnostic problems begin when a patient develops a neuropathic foot with clinical signs of inflammation, for example, ulceration, cellulitis, osteomyelitis and neuro-osteoarthropathy (Charcot foot). Clinical signs often are not conclusive in discriminating between infection (cellulitis or osteomyelitis) and neuro-osteoarthropathy (⁶). Early detection of feet at risk is preferable to help prevent these complications.

Diagnosing osteomyelitis is a well known challenge in diagnostic radiology (^{9, 10}). Magnetic resonance imaging (MRI) has been described as an important modality to

assess the neuropathic feet of diabetic patients (^{2, 5, 18}). For the detection of subtle bone marrow pathology it is mandatory to use fat-suppression sequences in state-of-the-art musculoskeletal MRI (¹⁴). A homogeneous fat-suppression in the entire field of view, both before and after intravenous contrast material [Gadolinium-chelate (Gd)] is necessary to avoid confusion (¹⁴). This can adequately be achieved by the use of two-point Dixon chemical shift imaging (TPD-CSI) (⁸).

The question was raised whether changes prior to the appearance of clinical signs are present and detected by early MRI. Since it is likely that early changes may occur, this lack of information may hamper the adequate reading of the MRI studies of symptomatic patients. All data available in the literature address clinically complicated neuropathic feet. To our knowledge, no papers concerning MRI in asymptomatic neuropathic feet exist.

In this study our goal was to answer the following questions: a) What is the MRI appearance of the asymptomatic neuropathic foot in leprosy patients? Are there MRI changes present in these patients? b) When changes are present, is there a role for MRI in relation to clinical management in the early assessment of the asymptomatic neuropathic foot in leprosy patients?

MATERIALS AND METHODS

Patients

From the database of the outpatient clinic of the Department of Dermatology, Academic Medical Center, Amsterdam, The Netherlands, 10 adult patients [5 male, 5 female; mean age 54 years (31–70 years)] with leprosy were selected. Inclusion criteria for entering this study were neuropathic feet with a normal or nearly normal foot, i.e., no Charcot deformity, no ulcer, and no signs of inflammation at the time of the

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study. The dermatologist in charge of the leprosy clinic (WRF) screened patients for inclusion. None of the feet had a history of osteomyelitis. The skin temperature was measured by palpation (7). No active ulcers and/or signs of inflammation were found. All patients entering the study signed an informed consent. The Medical Ethics Committee of our hospital approved the study.

A neuropathic foot was defined as a foot in which one or more of the neuronal functions, i.e., sensory, motor function or autonomic functions, were disturbed (consensus of the Dutch Neuropathic Foot Society). Sensory loss was tested using the Semmes-Weinstein monofilament test (1). Patients were included when the sensory loss was a 10-gram force.

MRI procedure

An MRI examination was performed using a 1.5 Tesla Vision (Siemens, Erlangen, Germany). The foot of interest was placed inside the circularly polarized head coil. This coil was used because it provided the best signal to noise ratio.

The MRI protocol consisted of: Sagittal Turbo-STIR (short tau inversion recovery) (3 mm), T1-weighted Dixon sequence (8), sagittal and coronal dual echo T2-weighted FSE (fast spin echo) (3 mm); after the administration of Gd intravenously T1-weighted Dixon sequence and coronal fat suppression T1-weighted. The MRI-examinations were evaluated by a musculoskeletal radiologist blinded to the clinical findings (MM).

RESULTS

Clinical findings (Table 1)

The right foot was examined in eight patients and the left foot in two patients. The shape of the foot was completely normal in six patients. Claw toes were present in two patients, and two patients showed minor deformities due to earlier disease. No ulcers were present. Callus was present in three patients, twice located beneath the first metatarsophalangeal (MTP) joint and once beneath the fifth MTP joint. Sensory function was impaired in all patients. Motor function was normal in seven patients. Three patients showed a paresis. The autonomic function, as demonstrated by dry

TABLE 1. Clinical demographics of the patients at the intake at the outpatient clinic.

No.	Sex	Age	Leprosy type ^a	Clinical history	Foot	Footform	Ulcer	Callus	Sensibility	Paresis	Skin
1	F	66	BL	Negative	Right	Claw toes	No	No	Impaired	No	Normal
2	M	69	LL	Negative	Left	Claw toes	No	No	Impaired	No	Hyperkeratosis
3	M	44	BL	Negative	Right	Normal	No	MTP1	Impaired	Peroneal nerve	Dry skin
4	F	48	LL	Negative	Right	Normal	No	MTP1	Impaired	Peroneal nerve	Normal
5	M	53	BL	Negative	Right	Normal	No	MTP5	Impaired	No	Dry skin
6	M	70	BT	Negative	Left	Normal	No	No	Impaired	No	Hyperpigmentation
7	F	41	BT	Negative	Left	Normal	No	No	Impaired	Next digitorum	Normal
8	F	47	Lepromatous	Ulcer distal phalanx Digit 1	Right	Claw toes	No	No	Impaired	No	Fissures
9	M	32	BL	Negative	Right	Normal	No	No	Impaired	No	Dry skin
10	F	46	Lepromatous	Negative	Right	Shortened dig IV, V	No	No	Impaired	No	Normal

^aBT = Borderline tuberculoid, BL = borderline lepromatous, LL = lepromatous leprosy, Lepromatous = lepromatous side of the spectrum.

TABLE 2. MRI results for all patients.

No.	Bone marrow edema	Effusion	Subcutaneous fat	Enhancement	Fistula/ulceration	Midfoot changes
1	No	MTP1	Infiltr. MTP 1, 2, 3, 4	No	No	Early osteoarthritis
2	No	MTP1	Infiltr. MTP 1	MTP 1	MTP 1	
3	MTP 1	MTP 1	Infiltr. MTP 1	MTP 1	No	
4	No	MTP 1	Intact	No	No	Early osteoarthritis
5	No	MTP 1	Infiltr. MTP 1	No	No	
6	No	No	Infiltr. MTP 1	No	No	
7	No	No	Infiltr. MTP 1	MTP 1	No	Early osteoarthritis
8	No	No	Intact	No	No	
9	No	MTP 1	Intact	No	No	
10	No	MTP 1	Intact	No	No	

skin and fissures, was impaired in five patients.

MRI findings (Table 2)

Bone marrow. In 9 of the 10 patients there was a normal MR signal in the bone marrow; no bone marrow edema was found. There was no bone marrow enhancement seen after administration of contrast material. No bone destruction was found.

Joints. Joint effusion was seen in seven patients, and in all of these patients located in the first MTP joint. Local contrast enhancement in the first MTP joint was present in three patients.

Soft tissue. Infiltration of the subcutaneous fat was depicted in six patients, and in all of these patients was located plantar to the first MTP joint. The skin was intact on the surface of the foot in 9 of the 10 patients. An unexpected fistula was found in one patient, located at the first MTP joint.

Midfoot. In two patients, early osteoarthritic changes were found in the midfoot. No disintegration of the tarsus was found.

DISCUSSION

MRI is the most valuable imaging technique in the evaluation of complications of the diabetic neuropathic foot^(9, 12, 17). The use of homogenous fat suppression in combination with contrast administration is found to be a very sensitive tool in evaluating neuropathic feet^(9, 11). All data are from diabetic patients, being by far the most common cause of neuropathic feet in the Western world.

This study is new because it includes leprosy patients who represent another impor-

tant cause of neuropathic foot pathology. We investigated clinically asymptomatic feet in order to acquire a baseline MRI for leprosy patients. Since it can be expected that in the future MRI will be part of the imaging protocols for leprosy patients with complications of a neuropathic foot, it is to be expected that MRI results will gain influence on clinical decision-making. This necessitates a study in clinical asymptomatic patients in order to acquire a baseline database of MRI findings. This may be the only way to adequately detect the changes that represent osteomyelitis in the complicated patient group.

The results that we found are remarkable. All of our patients had no clinical symptoms at the time of the MRI, yet MRI abnormalities were found in almost all patients. The most striking findings were the changes located in the region of the first MTP joint in the majority of patients (90%). These abnormalities ranged from degradation and interruption of the subcutaneous fat, plantar fascia, and a small fistula to effusion/synovitis in the first MTP joint.

The soft tissue damage in the foot, plantar to the first metatarsal bone, has been described in diabetic feet with a significant difference between neuropathic and non-neuropathic feet⁽³⁾. It was hypothesized that the subcutaneous lesions may consist of fibrosis⁽³⁾ or hemorrhage⁽⁴⁾. Moreover, it was suggested that the presence of this fatpad degradation might precede plantar ulceration. The same suggestion can be made in the leprosy population. Stress analysis studies in three-dimensional foot models of leprosy patients show that the

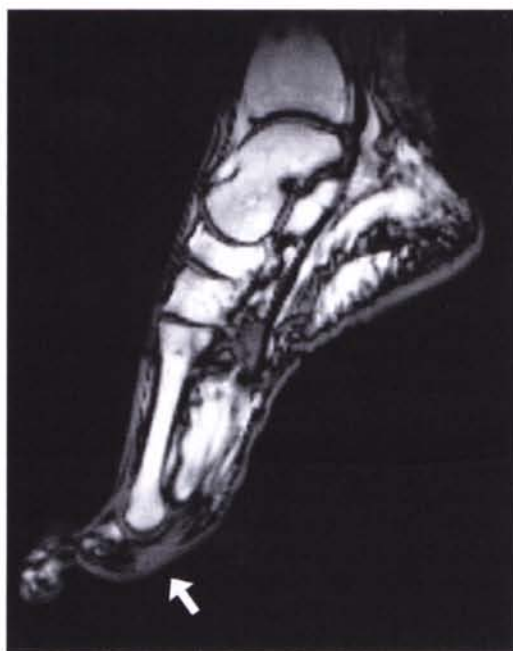


FIG. 1. Sagittal T1 out of phase Dixon image of the foot of patient 1. Note the normal plantar subcutaneous fat (with a bright signal). The interruption of the subcutaneous fat plantar to the metatarsophalangeal joint is illustrated with an arrow.

musculoskeletal stresses during walking are higher in leprosy patients than in healthy controls, being 24%–65% higher in early stage leprosy patients⁽¹³⁾. Patil, *et al.*⁽¹³⁾ conclude that the highest soft tissue stresses and shear stresses occur in the push off phase in scar tissue. The difference in shear stresses between the sole of the foot and the adjacent soft tissue layer in the scar tissue is about three times the normal value⁽¹³⁾. Since the push-off phase of the walking cycle takes place under the metatarsals, this may be related to the changes we found in our group of patients. Our findings support the conclusion that this may precede the development of plantar ulcers in these patients.

Our study reveals significant MRI findings in asymptomatic neuropathic feet in patients with leprosy. The changes we found with fat-suppressed contrast-enhanced MRI are possibly related to the future development of ulcerations. It is conceivable that these changes can be detected when a more thorough physical examination is performed. A consequence of this



FIG. 2. Detailed Sagittal Dixon fat sat water image of the first metatarsophalangeal joint of patient 7. Note the enhancement of the head of the first metatarsal bone (one arrow) and the joint effusion/synovitis (two arrows).

study could be that more attention is paid to the clinical examination of asymptomatic neuropathic feet.

Further research is necessary to investigate the potential role of MRI in the early detection of complications and its role in the clinical management of leprosy patients with neuropathic feet. Also, because of the recent introduction of less-expensive, dedicated extremity MRI, the implementation of MRI in the workup of leprosy patients may soon be possible outside the Western world.

SUMMARY

This study was undertaken to analyze the magnetic resonance imaging (MRI) findings in the clinically asymptomatic neuropathic feet of leprosy patients. Since in the literature no MRI data are available concerning the asymptomatic neuropathic foot in leprosy, the interpretation of MRI examinations in clinically suspected neuropathic feet in leprosy is difficult.

We examined 10 adult leprosy patients with clinically asymptomatic neuropathic feet. Inclusion criteria were a normal or near normal neuropathic foot, without signs of inflammation. All patients underwent an

MRI protocol with the inclusion of two-point Dixon chemical shift imaging as fat suppression sequence. We found MRI changes in almost all patients. The most striking were the changes located in the region of the first metacarpophalangeal (MTP) joint. These changes ranged from degradation and interruption of the subcutaneous fat to effusion/synovitis in the first MTP joint.

This study reveals significant MRI changes in clinically asymptomatic neuropathic feet in patients with leprosy. These changes may relate to the development of ulcerations. MRI may play an important role in detecting feet at risk and may influence clinical decision making.

RESUMEN

Se hizo el estudio del pie con neuropatía clínicamente asintomática en los pacientes con lepra utilizando la resonancia magnética de imagen (RMI). Puesto que no hay datos en la literatura sobre la aplicación de la RMI en este tipo de neuropatía, los resultados obtenidos con esta técnica resultan algo difícil de interpretar.

Examinamos 10 pacientes adultos con lepra, con neuropatía del pie clínicamente asintomática. El criterio básico de inclusión fue que los pacientes tuvieran un pie neuropático clínicamente normal o casi normal, sin signos de inflamación. Todos los pacientes se sometieron al examen por RMI, el cual incluyó el cambio de imagen de los puntos (Dixon) y una secuencia de supresión de grasa. Encontramos anomalías en la RMI en casi todos los pacientes. Los cambios más marcados estuvieron localizados en la región de la primera articulación metacarpofalángica (MTP). Estos cambios variaron desde la degradación e interrupción de la grasa subcutánea, hasta la efusión y sinovitis en la primera articulación MTP.

El estudio revela cambios significativos en la RMI en el pie neuropático, clínicamente asintomático, de los pacientes con lepra. Como estos cambios pueden estar relacionados con el desarrollo de ulceraciones, la RMI podría ser de utilidad en la detección del pie en riesgo, y podría ayudar a decidir el manejo clínico de los pacientes y su tratamiento.

RÉSUMÉ

Cette étude a été entreprise pour analyser les données obtenues par résonance magnétique nucléaire (RMN) sur les pieds neuropathiques mais cliniquement asymptomatiques de patients hanséniens. Comme la littérature ne contient pas de données au sujet des pieds neuropathiques asymptomatiques de la lèpre, l'interprétation des examens RMN est difficile parmi les cas cliniquement suspects de pieds neuropathique dans le cadre de la lèpre.

Nous avons examinés 10 patients adultes han-

séniens avec des pieds neuropathiques cliniquement asymptomatiques. Les critères d'inclusion dans l'étude étaient un pied neuropathique normal ou presque normal, sans signe d'inflammation. Il a été réalisé chez tous les patients un protocole de RMN incluant une dérive chimique de Dixon en deux points comme séquence de suppression du tissu adipeux. Chez presque tous les patients, des modifications furent détectées par RMN. Les plus évidentes furent des modifications localisées à la région de la première jointure métatarso-phalangienne (MTP). Ces modifications s'étendaient de dégradation et d'interruption du tissu adipeux sous cutané à des épanchements synoviaux/synovites de la première jointure MTP.

Cette étude révèle des modifications RMN significatives chez les pieds neuropathiques asymptomatiques chez les patients lépreux. Ces modifications pourraient être liées au développement d'ulcérations. La RMN pourrait jouer un rôle important pour détecter les pieds à risque et pourrait influencer les prises de décisions cliniques.

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