Clinical applications of Dixon chemical shift MR imaging: Morbus Gaucher, Morbus Hansen
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MRI in clinically asymptomatic neuropathic leprosy feet: A baseline study

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**INTRODUCTION**

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 (TPDCSI) [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 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 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) (3mm), T1-weighted Dixon sequence [8], sagittal and coronal dual echo T2-weighted FSE (fast spin echo) (3mm); after the administration of Gd intravenously T1-weighted Dixon sequence and a coronal fat-suppression T1-weighted sequence. The MRI-examinations were evaluated by a musculoskeletal radiologist blinded to the clinical findings (MM).
### 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.
MRI in asymptomatic leprosy patients

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 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.

**Table 2. MRI results of all patients.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Bone marrow edema</th>
<th>Effusion</th>
<th>Subcutaneous fat</th>
<th>Enhancement</th>
<th>Fistula/ulceration</th>
<th>Midfoot changes</th>
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<td>no</td>
<td>early osteoarthritis</td>
</tr>
<tr>
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<td>no</td>
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<td>infiltr. MTP1</td>
<td>MTP1</td>
<td>MTP1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>MTP1</td>
<td>MTP1</td>
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<td>MTP1</td>
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</tr>
<tr>
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<td>no</td>
<td>no</td>
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</tr>
<tr>
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<td>6</td>
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</tr>
</tbody>
</table>

**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 homogeneous 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 important 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 future MRI will be part of 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 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%) (Figure 1 and 2).

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 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 more thorough physical examination is performed. A consequence of this 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 clinical 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 metatarsophalangeal (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.

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MR II in asymptomatic leprosy patients

REFERENCES


Chapter 3


