MRI HASTE diffusion in the investigation of limb infection: a safe quick method for identifying surgically relevant collections

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Aims and objectives

Limb infection can lead to septicemia, limb loss and death. Early infection including osteomyelitis may be treated medically[1], [2], however the presence of necrosis or an abscess is an indication for early invasive management [3], [4].

Traditionally a walled off collection was identified by demonstrating a thick enhancing wall by the administration of gadolinium on either T1 or fat suppressed T1 sequences[5].

However many of the patients susceptible to these infections have co existent diabetes, up to 82% in one series [6]. The increase risk of retroperitoneal fibrosis with the administration of gadolinium in the presence of renal impairment has been recognised[7] and for this reason intravenous gadolinium is often withheld for the investigation of distal limb infection in the presence of chronic renal failure.

The sensitivity of diffusion weighting imaging (DWI) for identifying collections has been established in the setting of soft tissue infection[8], [9]. However artefacts from bone/air interfaces are common with echo planar imaging (EPI) based DWI.

Half-Fourier acquisition single-shot turbo spin- echo diffusion weighted imaging (HASTE DWI) a turbo spin echo technique, has been used in the temporal bones successfully to identify densely cellular cholesteatomas [10]. Non EPI DWI has recently shown high specificity and sensitivity in the investigation of cholesteatoma in the middle ear[11-13].

To our knowledge HASTE DWI has not previously been applied to identify intra-osseous, soft tissue and intra-articular collections in suspected cases of infection.
Methods and materials

Retrospective analysis was performed on 93 MRI referrals for presumed foot or ankle infection. Clinical follow up was performed for all cases. The sensitivity and specificity of HASTE DWI to identify collections was compared to post contrast imaging in addition to clinical follow up. All cases with surgical debridement had tissue sent for microbiology.

Patients

From January 2011 to March 2013, 93 MRIs have been included in our database. The database collated information on clinical, radiological, microbiological and surgical findings where available. 21 patients did not have gadolinium administered due to GFR <30mls. 67 of 93 were diabetic and 87 had a clinical ulcer identified by the referring team.

Imaging Technique

MR imaging was performed with a 1.5T (Magnetom Avanto, Siemens, Erlangen, Germany) MRI scanner utilising an 8-channel foot/ankle coil.

T1 and T2 fat saturated (STIR when appropriate), sagittal, coronal and axial images were acquired pre contrast administration. This was followed by three plane T1FS following intravenous injection (when clinically suitable) of 0.1 mmol/kg body weight of gadopentate dimeglumine (Magnevist, Schering, Berlin, Germany). Finally, sagittal and axial diffusion weighted images were obtained with Half-Fourier acquisition single-shot turbo spin-echo (HASTE) sequences. Slice thickness is 5mm with a voxel size of 1.6*1.3*5mm (axial), 2.1*1.7*5mm (sagittal) and a b value of 1000 s/mm².

Imaging Evaluation

A single evaluator, reviewed images with 3 years experience in musculoskeletal MRI. The criteria for diagnosis of collection were high signal intensity on the fluid weighted sequences with corresponding high signal on the TSE HASTE DW MRI sequence.
Results

HASTE DWI MRI detected and precisely localised collections in 42 patients, 29 of which were treated surgically and the remainder treated conservatively with IV antibiotics (fig 1-9.)

HASTE DWI failed to detect collections in 4 patients. These patients had collections that were too small to demonstrate separate from presumed artefact. Three studies suggested collections on the DWI studies which were later shown to be otherwise, one case of acute gout, mid foot arthralgia and one case demonstrated presumed focal acute muscle denervation.

HASTE DWI detected collections that were not identified by post contrast images in 2 cases, one was a superficial thin walled abscess which demonstrated pus at theatre and a second collection was demonstrated at the base of the 5\textsuperscript{th} metatarsal which did not demonstrate restricted diffusion.

The false negatives were felt to be due mostly due to incomplete fat suppression and the subsequent loss of conspicuity of small peripheral lesions in the forefoot.

In our study HASTE DWI when combined with T1 and STIR sequences was shown to have a specificity of 92\% and sensitivity of 91\% for intra-articular, soft tissue and osseous collections when compared to clinical follow up and surgical findings.
Fig. 1: Axial T1 shows evidence of cortical erosion and reactive oedema and osteomyelitis.

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**Fig. 2**: HASTE DWI axial image of patient from Fig 1 with hyperintense focus representing focal abscess (arrow.)

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**Fig. 3:** Corresponding T1 FS post contrast image from Fig 1 heel ulcer with focal abscess (arrow) and evidence of necrosis.

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Fig. 4: A distal fibular subperiosteal abscess with sinus bone tract and medullary abscess demonstrated as an area of hyperintense focus on HASTE DWI.

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**Fig. 5:** Focus of restricted diffusion in the second metatarsal phalangeal joint in keeping with septic arthritis (arrow.)

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**Fig. 6:** HASTE DWI sagittal image demonstrating focal collection in the small muscles in the forefoot.

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**Fig. 8:** AXIAL STIR demonstrating high signal in the flexor tendons of the third and forth toes.

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**Fig. 9:** Axial HASTE DWI corresponding image from Fig 8 demonstrating restricted diffusion in the flexor tendons previously mentioned. The restricted diffusion is highly suggestive of septic tenosynovitis.

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<table>
<thead>
<tr>
<th>Surgical follow up</th>
<th>No collection on HASTE DWI</th>
<th>Collection on HASTE DWI</th>
<th>Total</th>
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<tbody>
<tr>
<td>Collection</td>
<td>4</td>
<td>41</td>
<td>45</td>
</tr>
<tr>
<td>No collection</td>
<td>45</td>
<td>3</td>
<td>48</td>
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</table>

**Fig. 10:** Summary of results, HASTE DWI vs surgical follow up.

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Conclusion

This initial study demonstrates that HASTE DWI can identify collections in the foot and ankle to a similar sensitivity and specificity to contrast enhanced sequences with the advantage of reduced scanner time, cost and increased patient safety.
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References


