Integration of the Tim Planning in Protocol Development for Multi-Region Scanning

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Introduction

The advent of the Total imaging matrix (Tim) system, integrated Parallel Acquisition Techniques, and more recently the *syngo* Tim Planning Suite and Inline Composing has had a significant impact on the ease of use and workflow in cases where multiple body areas need to be examined in a single sitting. The Tim Planning Suite and Inline Composing in particular have allowed us to simplify and streamline our protocols for a number of exams, ranging from simple spinal cord compression cases to more complex whole body screening procedures. The Tim Planning user interface (UI) is of great benefit in planning multi area and whole body exams as the full extent of coverage can be seen in a single composed scout image and protocols can be adjusted and planned to minimize patient examination time as well as ensuring full coverage of the area under examination. This is particularly true in spinal cases where the whole spinal cord can be quickly scouted and the composed image displayed for accurate protocol planning. This is also of great benefit in patients with extensive MSK tumors where tumor extent can be readily seen on the scout images and subsequent imaging can be easily planned. More recently we have used the *syngo* Tim Planning Suite to develop an efficient protocol for evaluation of patients with limb girdle muscular dystrophies.

Background [1]

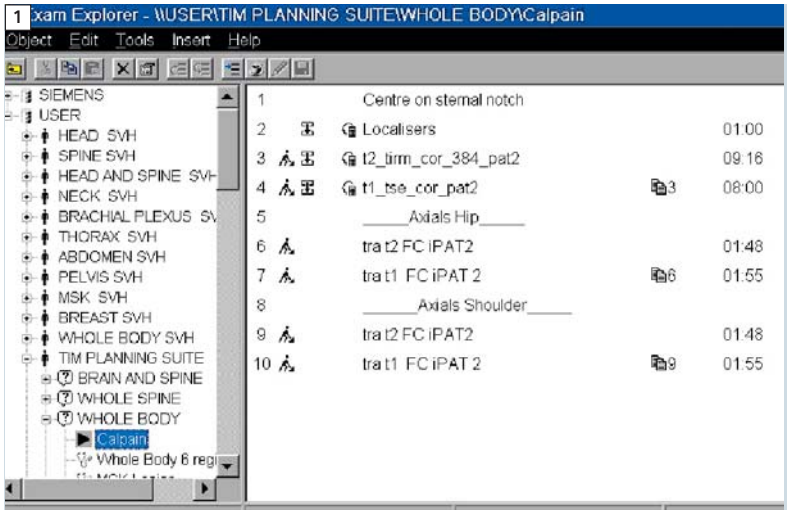
The Limb Girdle Muscular Dystrophies (LGMDs) are a heterogenous group of 16 genetic conditions, first described in the 1960s. Accurate diagnosis of the individual LGMD is important, as each LGMD may have different genetic implications and prognostic outcomes, including the presence of associated cardiac and respiratory complications.

LGMD-2A, the most common of the LGMDs, is caused by a deficiency of Calpain-3 – a muscle specific protease. Diagnosis of a LGMD-2A can be difficult and is based on recognising the clinical phenotype and demonstrating a calpain abnormality. A calpain abnormality is identified on Western Blot analysis, as a reduced or absent protein band. Calpain abnormalities, however, can occur as a secondary phenomenon in other muscle disorders as well.

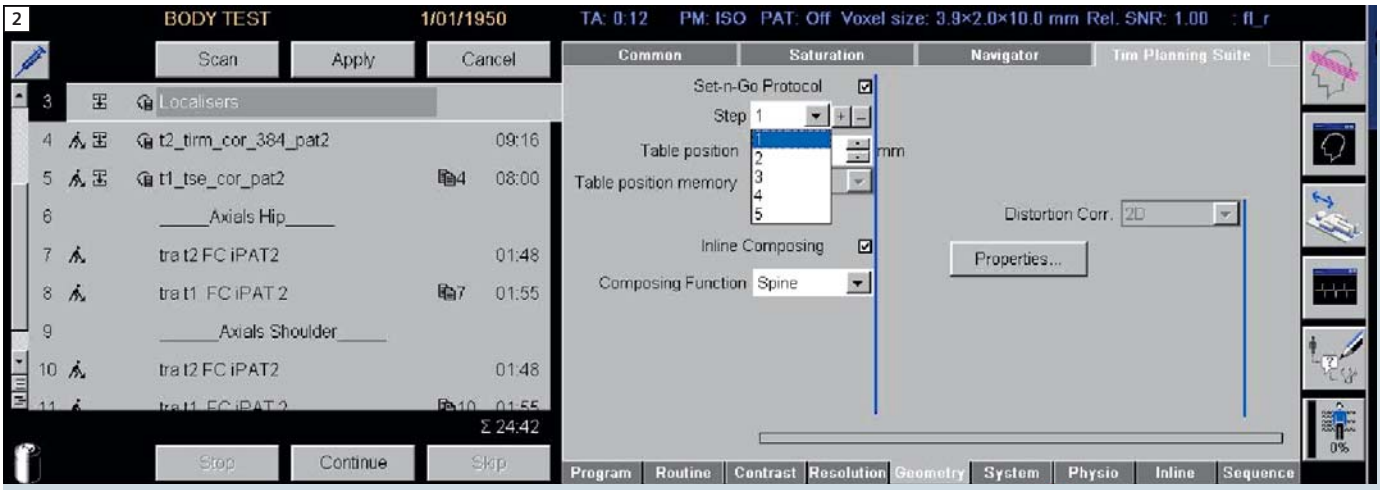
To confirm the diagnosis of a LGMD-2A, a genetic abnormality in Calpain should be demonstrated with molecular sequencing of the gene. Molecular sequencing of Calpain is an expensive and time-consuming technique, currently performed only in limited centres in Australia. Accurate identification of potential LGMD-2A patients is therefore important, to aid in quicker diagnosis and selection of patients for molecular sequencing. The muscular dystrophies typically have selective involvement of particular muscle groups. Magnetic resonance imaging (MRI) can be used to accurately highlight the muscle groups affected. The neuroimaging profile obtained may be a useful tool to facilitate more accurate and rapid diagnosis.

Technical considerations

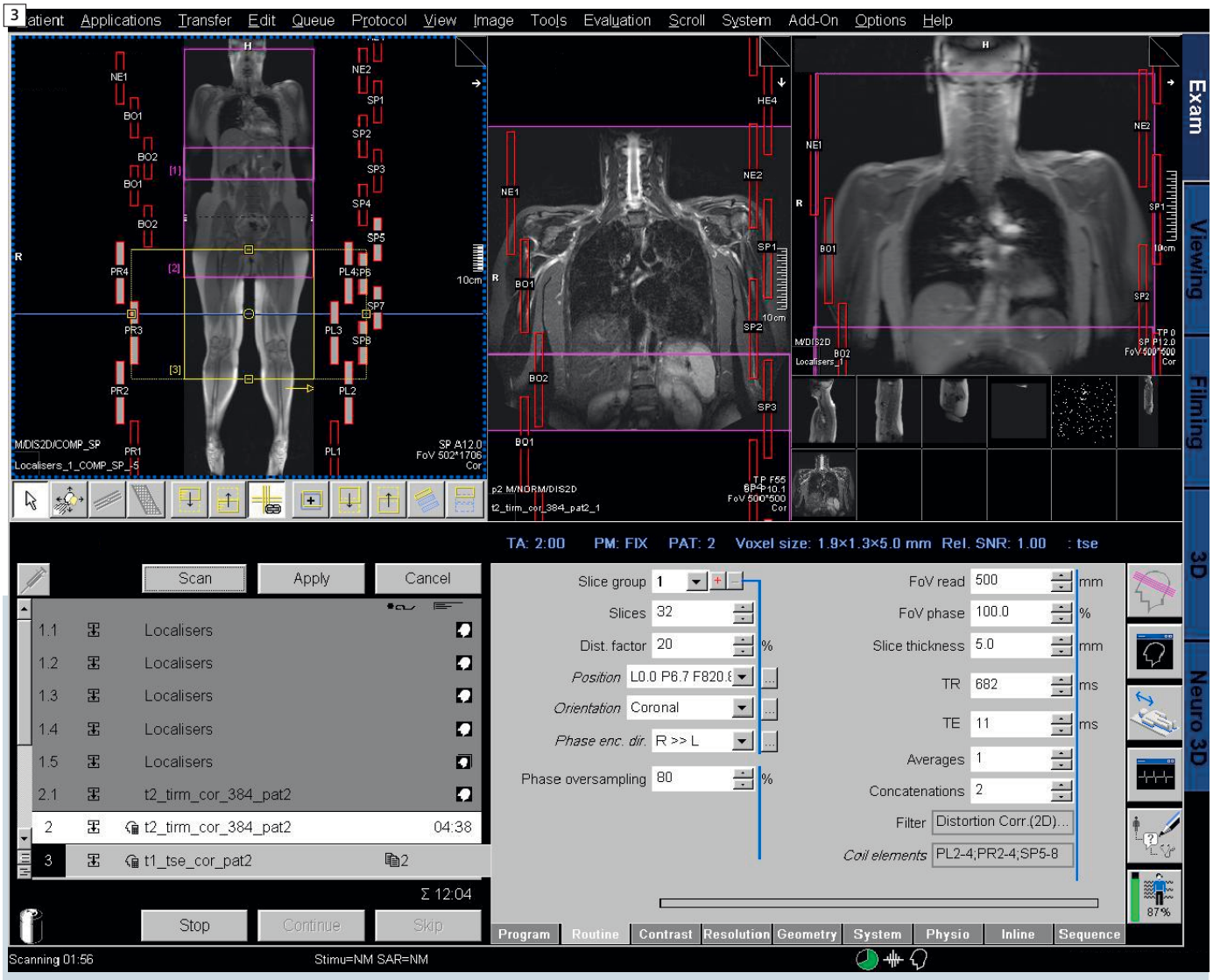
All examinations were performed on a 1.5T MAGNETOM Avanto 76 x 32 machine. The MRI protocol was designed not only to primarily demonstrate muscle changes in the hip and shoulder girdles, but also to demonstrate paraspinal, thigh, and calf muscles. The protocol needed to have a high degree of patient tolerance and accommodate a large range of body types. It also needed to be easily



1 Saved Calpain protocol in the protocol tree.



2 Localiser showing Set-n-Go protocol with 5 table positions.



3 Localiser showing positioning of coronal T1. Coupled graphics and AutoCoil Select are turned on.

implemented by our technological staff and not compromise the workflow in our busy department.

Patient set-up: After completing a standard MRI safety questionnaire, patients were given a full explanation of the procedure. They were positioned head first on the MRI table, with shoulders comfortably against the Neck Matrix coil. Coils were positioned from the feet towards the head and all patients were given hearing protection and instructed in the use of the emergency call system

Coils: As well as the posterior elements of the Head, Neck, and Spine Matrix, both Body Matrix and the Peripheral Angio Matrix coils where used. The anterior Neck Matrix coil was used in all bar one case, where the patients' size and body habitus precluded its use. The anterior Head Matrix coil was not used, and this aided greatly in patient comfort. The short bore magnet ensured that the patients head was outside the bore for over 50% of the imaging time. The sternal notch was used as a common centring point for all patients.

Sequences: The Tim Set-n-Go protocol facility was used to provide a simplified protocol tree which could be easily implemented in the Tim Planning UI (Fig. 1). A whole body scout is performed using Inline composing to cover from the neck to the ankle (Fig. 2). This is then used to proscribe coronal STIR and T1-weighted sequences to cover the whole shoulder

Study methods / results [1]

14 patients with a muscular dystrophy or inherited myopathy were included in this study. Nine patients have likely LGMD-2A. Five patients, with confirmed diagnoses of other muscular dystrophies or inherited myopathies, were included. Two patients have facioscapulohumeral muscular dystrophy (FSH), with clinical similarities to a typical LGMD phenotype. Three patients with a distal presentation were included, to observe the differences in distal pattern seen.

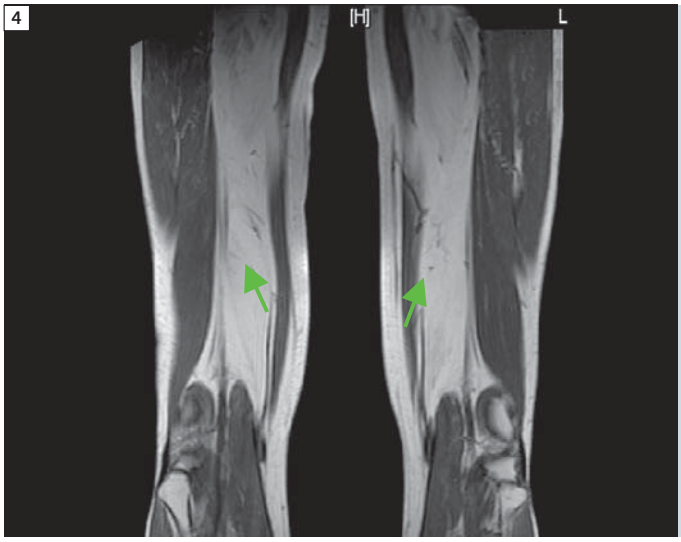
PATIENT (MF, AGE)	CLINICAL PHENOTYPE	WESTERN BLOT	DIAGNOSIS				
				SHOULDER GIRDLE And ARM	TRUNK	PELVIC GIRDLE AndTHIGH	CALF MUSCLES
1 M24	LGMD Shoulder & Pelvic	Reduced Calpain	Calpainopathy -LGMD	Biceps, Rotator Cuff, Serratus Anterior,	Erector Spinae	Gluteus Maximus, Adductors, Hamstrings	Posterior Compartment-Medial Gastroc, Soleus
2 M58	LGMD Shoulder & Pelvic	Reduced Calpain	Calpainopathy -LGMD	Rotator Cuff, Serratus Anterior,	Erector Spinae	Gluteus Maximus, Adductors, Hamstrings	Posterior Compartment-Medial Gastroc
3 M72	LGMD Shoulder & Pelvic	Reduced Calpain	Calpainopathy -LGMD	Rotator Cuff, SerrAnt Trapezius, Lat Dorsi	Erector Spinae	Gluteus Maximus, Adductors, Hamstrings	Posterior Compartment-Soleus
4 F 76	LGMD Shoulder & Pelvic	Reduced Calpain	Calpainopathy -LGMD	Latissimus Dorsi		Gluteus Maximus, Hamstrings	Posteriot Compartment-Medial Gastroc, Soleus
5 M29	LGMD Pelvic Girdle	Reduced Calpain	Calpainopathy -LGMD	Latissimus Dorsi		Gluteus Maximus, Adductors, Hamstrings	Posterior Compartment-Medial Gastroc
6 M34	LGMD Pelvic Girdle	Reduced Calpain	Calpainopathy -LGMD			Gluteus Maximus, Hamstrings	Posterior Compartment-Medial Gastroc, Soleus
7 F42	LGMD Pelvic Girdle	Reduced Calpain	Calpainopathy -LGMD			Gluteus Maximus, Adductors, Hamstrings	Posterior Compartment-Medial Gastroc
8 M44	LGMD Pelvic Girdle	Reduced Calpain	Calpainopathy -LGMD			Gluteus Maximus, Hamstrings	Posterior Compartment-Medial Gastroc, Soleus
9 F58	LGMD Pelvic Girdle	Reduced Calpain	Calpainopathy -LGMD		Erector Spinae		Posterior Compartment-Medial Gastroc
10 M64	FSH		Facioscapulo-humeral dystrophy	Rotator Cuff, Serr Ant, Trapezius, Pectoralis, Biceps, Triceps		Hamstrings	Anterior Compartment-Tibialis Anterior
11 M65	FSH		Facioscapulo-humeral dystrophy	Biceps, Rotator Cuff, Pectoralis, LatDorsi			Anterior Compartment-Tibalis Ant, Peroneals
12 M29	Distal Leg Weakness	Absent Dysferlin	Dysferlinopathy -Miyoshi myopathy			Adducotrs, Abductors, Quadriceps	Posterior Compartment-Medial/Lat Gastroc, Sol, Anterior Compartment
13 F15	Distal Leg Weakness		Hereditary Inclusion Body Myopathy			Gluteus Maximus, Hamstrings	Anterior and Posterior Compartment
14 M40	Distal Leg Weakness		Hereditary Inclusion Body Myopathy			Adductors, Hamstrings	Anterior and Posterior Compartment

and hip girdle, thigh, and calf if necessary (Fig. 3). Thirty-two 5 mm slices are used for each table position to ensure consistent composing throughout the whole body, and 3 or 4 table positions are used to cover the regions of interest. These could be easily identified and planned on the UI to keep exam time to a minimum. Transverse T1 and T2 images are then obtained of both shoulder and hip girdles. The history function is used for both coronal and axial slices, so sequence set up time is kept to a minimum. After the initial coronal STIR set up on the scout image, scanning is continuous, except for table moves. This keeps total exam time down to approximately 30 minutes.

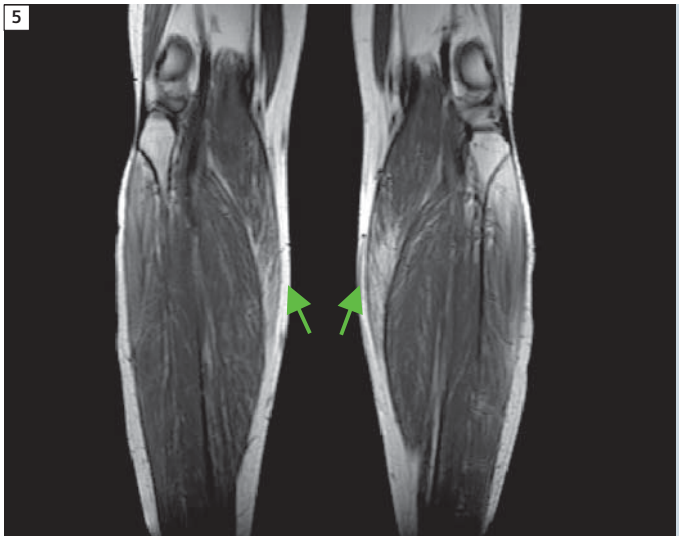
Technical outcomes

The imaging objectives of this study have been achieved and the scanning protocol has been very well tolerated by this group of patients. The short exam time and consistent high quality of the MR images has been made possible by the use of the Tim planning suite, Set-n-Go protocols, Inline Composing, integrated matrix coils, and integrated Parallel Acquisition Techniques (iPAT). These tools have made it possible to efficiently integrate what would have been in the past a cumbersome and time consuming exam, into our daily schedule.

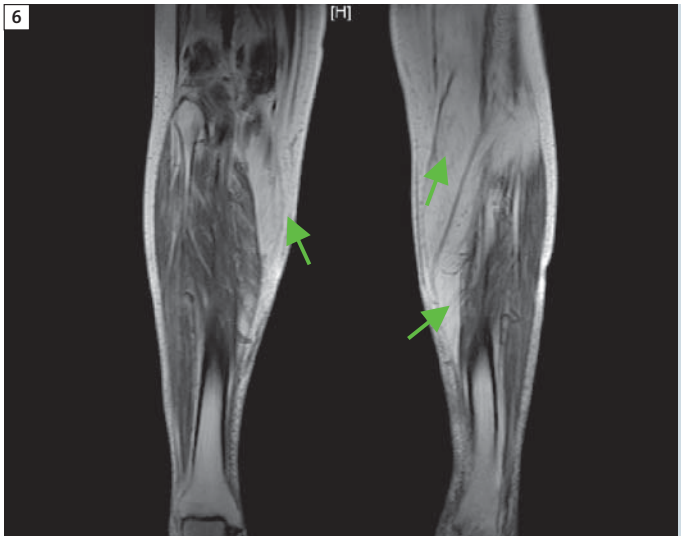
Postero-medial compartment of proximal thigh and posterior compartment of the leg



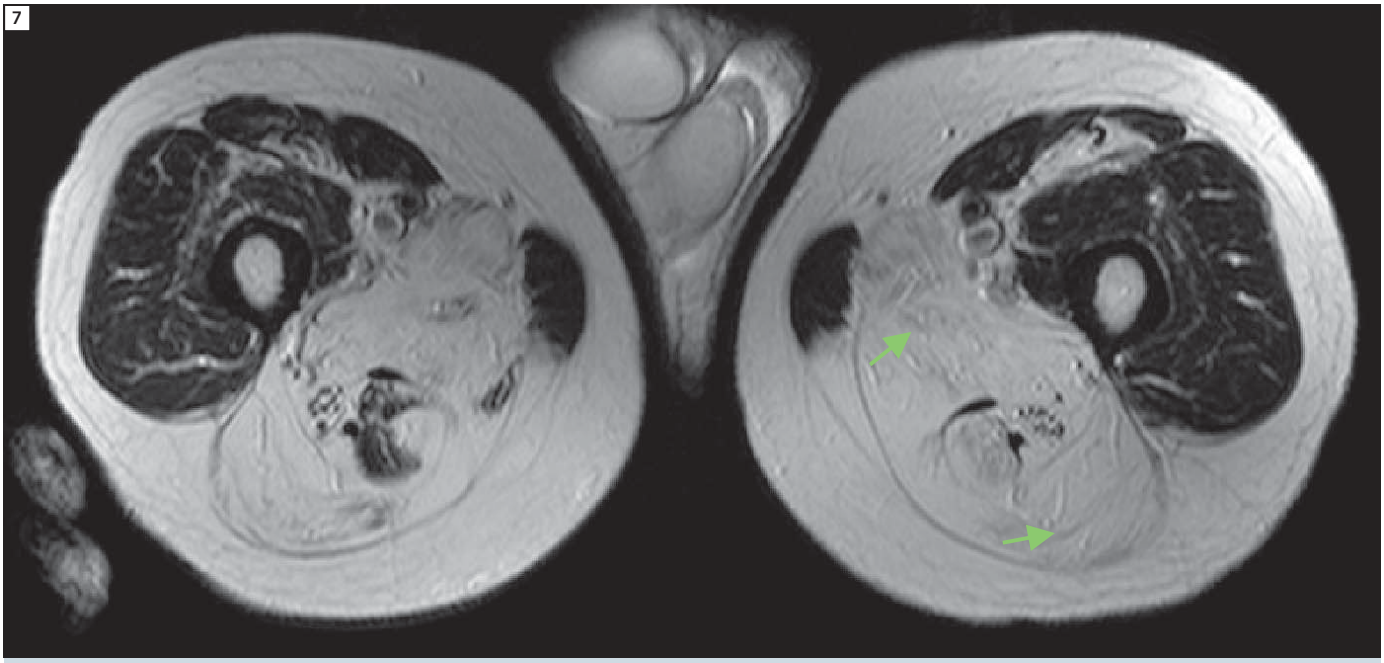
4 Coronal T1-weighted image of the posterior thigh of Patient 3 (LGMD). There is gross fatty replacement of the semimembranosus and semitendinosus muscles, with relative sparing of the biceps femoris.



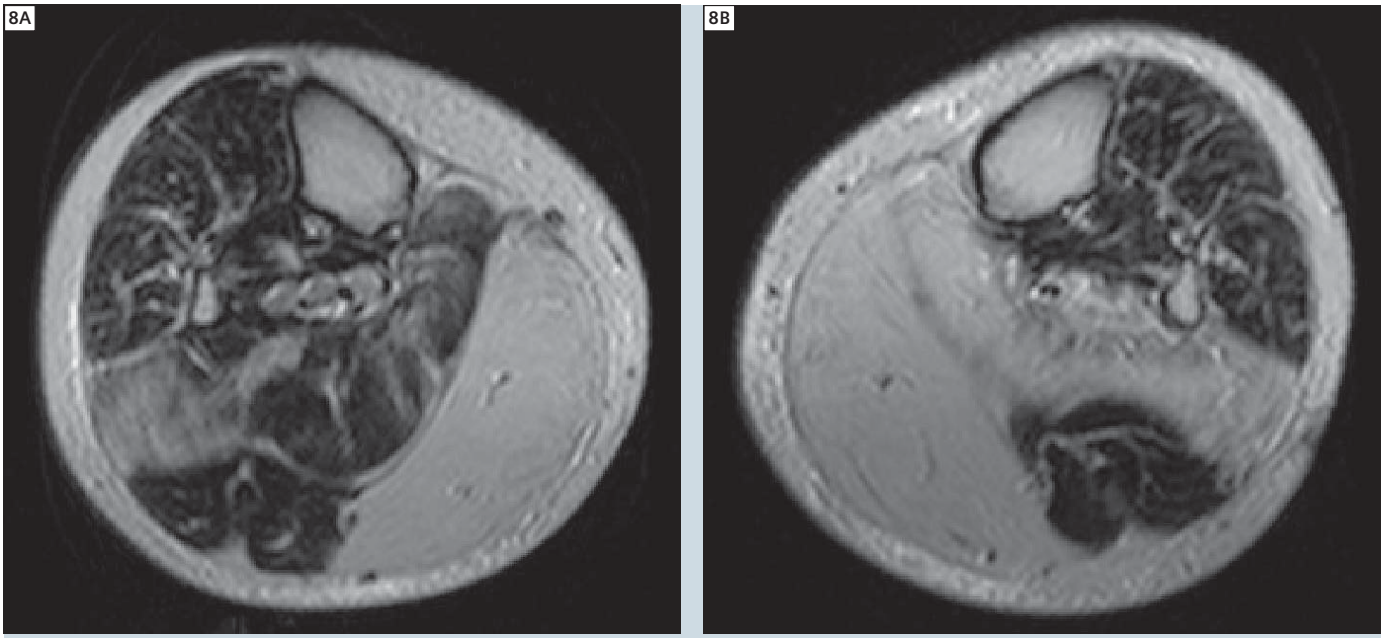
5 Coronal T1-weighted image of the lower leg of Patient 5 (LGMD). There is early preferential focal atrophy and fatty replacement of medial gastrocnemius.



6 Coronal T1-weighted image of the lower leg of Patient 4 (LGMD). There is preferential focal atrophy of medial gastrocnemius, with sparing of lateral gastrocnemius.



7 Axial T2-weighted image of the proximal thigh of Patient 3 (LGMD). There is gross fatty replacement of the gluteus maximus and the adductor muscles.

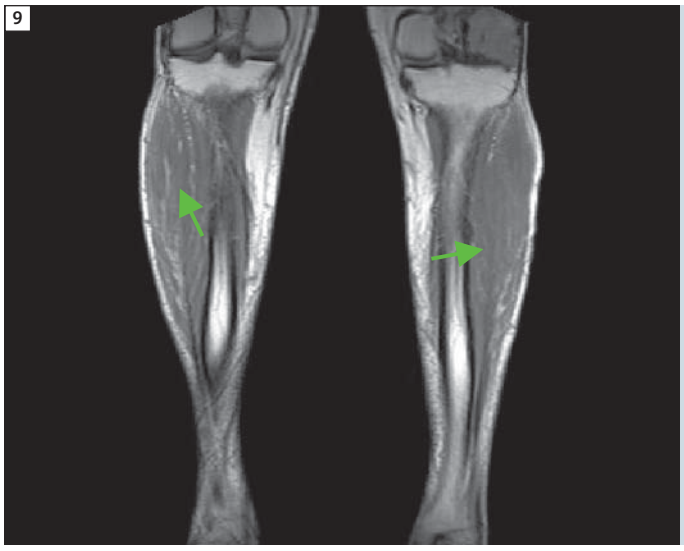


8 Axial T2-weighted image of the lower leg of Patient 4 (LGMD). There is fatty replacement of the medial gastrocnemius muscles bilaterally and the left soleus muscle.

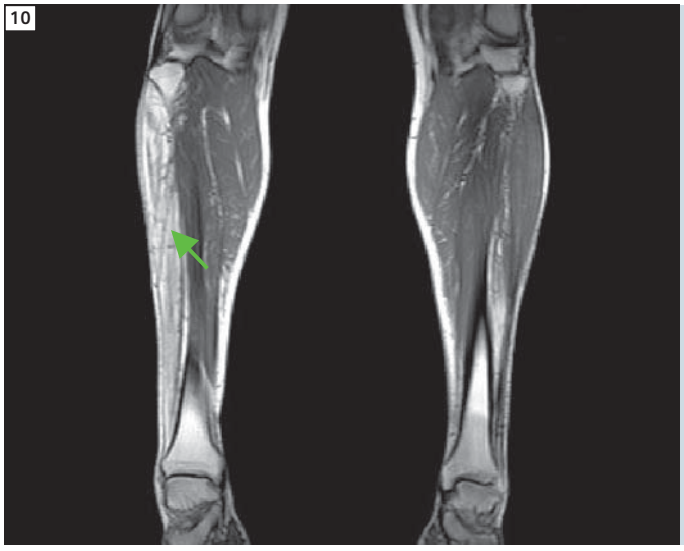
Conclusions [1]

MRI can be used to obtain an accurate neuroimaging profile of the specific muscle groups affected in muscular dystrophies.
The muscles preferentially affected in the calpain-related LGMD are:
Pelvic Girdle: Hip adductors and hip extensors.
Hamstrings: Especially semimembranosus and semitendinosus muscles.
Posterior compartment: Especially medial gastrocnemius.
Upper Limb: Latissimus dorsi, rotator cuff muscles and serratus anterior.
The neuroimaging profile on MRI is a useful technique to aid in accurate diagnosis and differentiation of the individual muscular dystrophies.

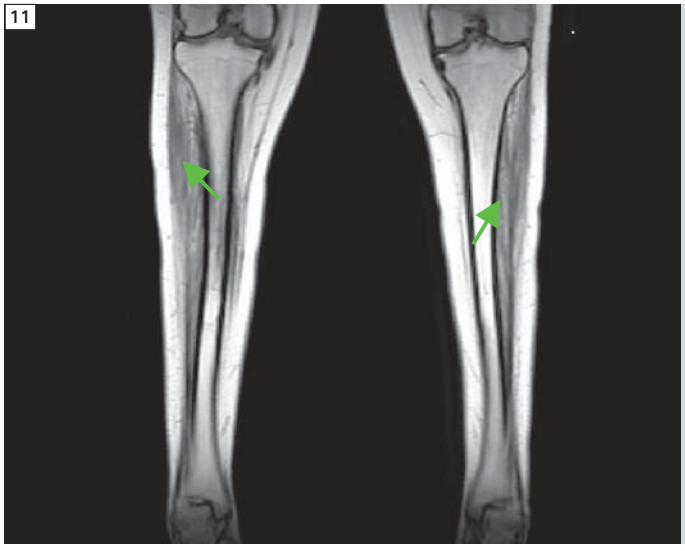
Anterior compartment of the leg



9 Coronal T1-weighted image of the lower leg of Patient 2 (LGMD). There is preservation of anterior compartment muscles.

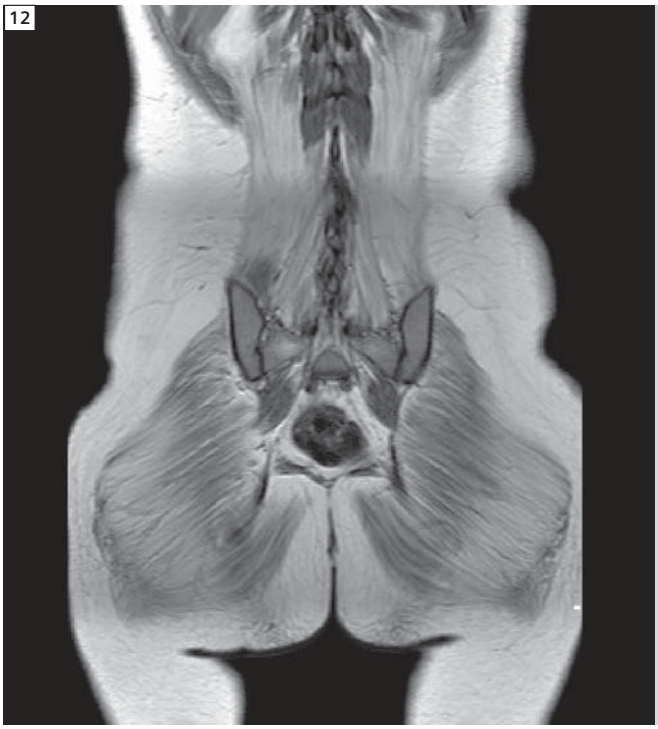


10 Coronal T1-weighted image of the lower leg of Patient 11 (FSH). There is atrophy and fatty replacement of the right anterior compartment.



11 Coronal T1-weighted image of the lower leg of Patient 13 (hIBM). There is gross atrophy of the anterior compartments bilaterally.

Paraspinal muscles



12 Coronal T1-weighted image of the posterior back of Patient 1 (LGMD). There is atrophy and fatty replacement of the lumbar paraspinal muscles and the gluteal muscles.

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References

1 Neuroimaging profile in the Muscular Dystrophies: Role of Magnetic Resonance Imaging
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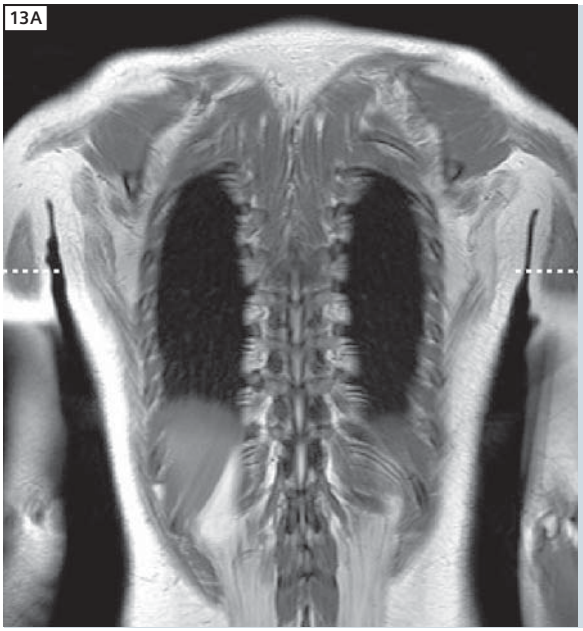
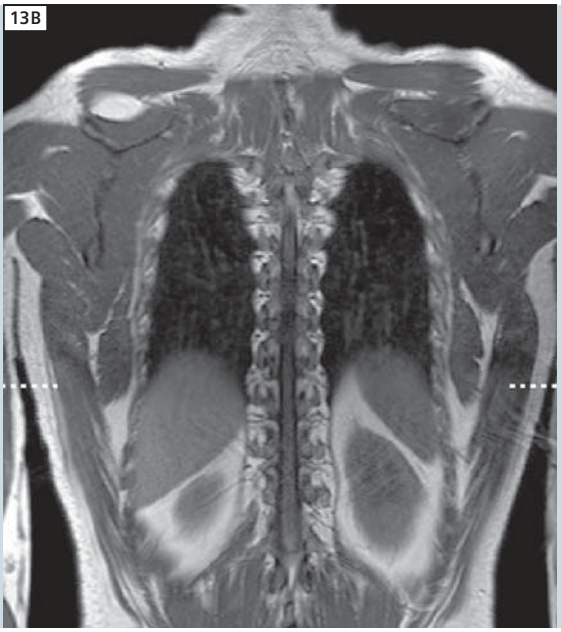
Upper limb muscles





13 Coronal T2-weighted images of the posterior thoracic wall of Patient 1(LGMD), on the left (A), showing atrophy of the latissimus dorsi. A normal appearance is shown on the right. (B)