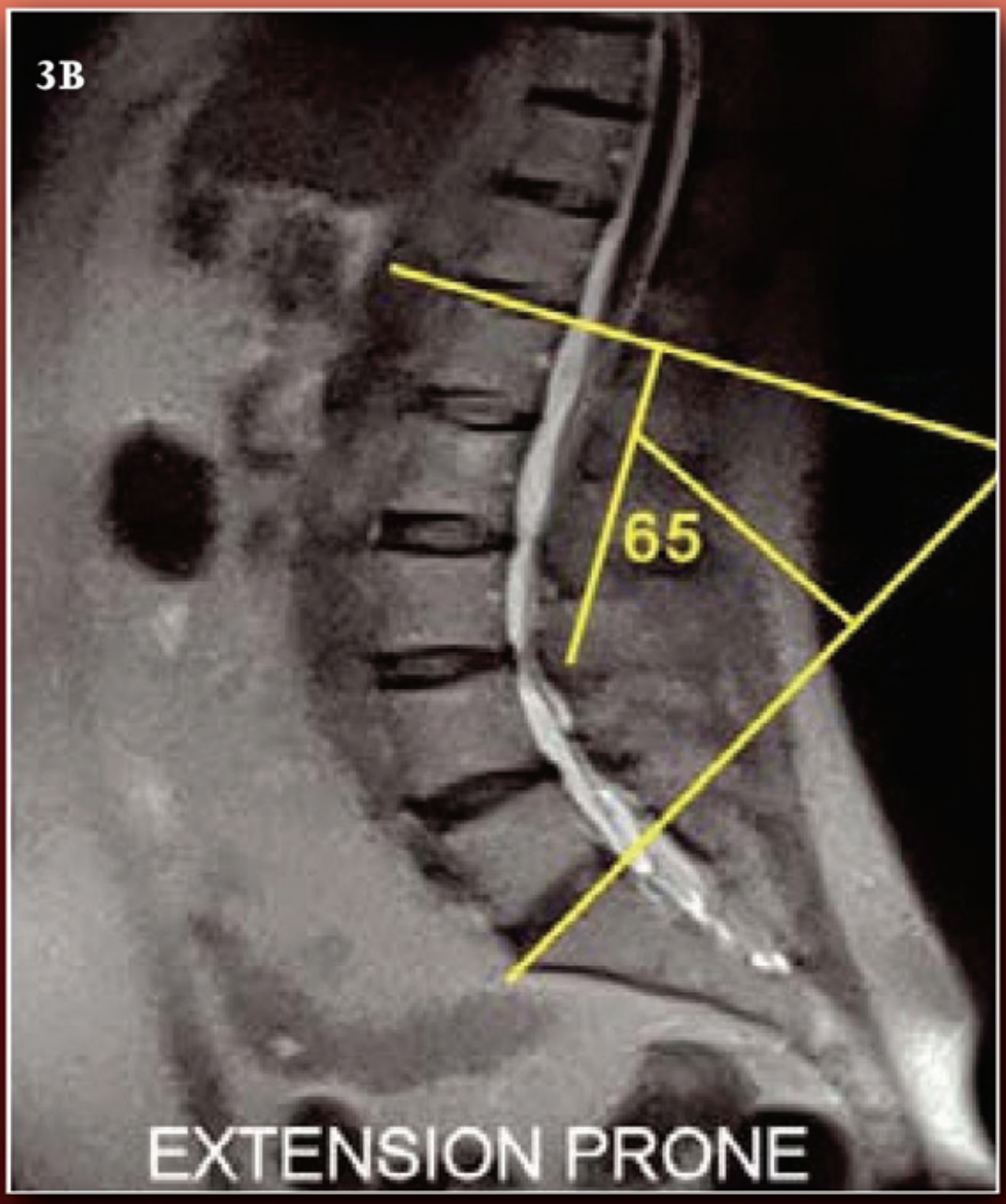
ISSUE 43
SPRING 2013

BAMRR

news

THE NEWSLETTER OF THE BRITISH ASSOCIATION OF MR RADIOGRAPHERS



MAKING HASTE
CHALLENGING TRADITION IN LANCASHIRE

LEICESTER CONFERENCE
FULL REPORT

IDENTITY CRISIS
PROBLEMS WITH INK

welcome from your BAMRR PRESIDENT

Welcome to the spring newsletter. The new BAMRR website has been launched and you should have all received your username and the link for your password. We experienced some initial teething problems and we thank you for your patience during this transition period of the website. It is still a work in progress and we hope it will become a useful resource for you to use.

The policy board are committed to providing educational courses for MR radiographers at all levels. At the end of June we are running the "further" MRI course to follow on from the successful introductory MRI course that took place in London last spring. The course will have a coastal feel at the new venue of Bournemouth.

The conference will take place in Bristol this year and we hope to see you all at this popular event in the MRI calendar so make a note in your diary. We aim to keep the cost of the conference at a reasonable price to encourage as many radiographers to attend as possible.

Don't forget your to renew your BAMMR membership this is now on a rolling year so you have a full years membership whenever you join!

Janine Sparkes

President

from your EDITOR

I hope you enjoy the selection of articles included in this Newsletter – the last issue I will be editing. I am handing the reigns to Jill McKenna who joined the Policy Board in 2012. Jill is a very experienced MRI Professional and I am sure with your help will take the Newsletter forward and continue to be a platform for BAMRR and the wider MRI community. By the time you read this the following technical articles can be found in previous Newsletters published from 2010 to 2012 on the BAMRR website - in alphabetical order (Members Area only).

Ataxia Telangiectasia	Autumn 2012
Breast feeding and MR contrast agents	Winter 2010
Diffusion MRI - 4 articles	Spring 2011
Holistic approach to the patient experience	Spring 2012
Implants – safe to scan?	Summer 2010
In contrast – blood pool contrast agents	Summer 2010
Magic Angle Phenomenon	Autumn 2011
Mr MRI – Sir Peter Mansfield story	Winter 2010
Pacemakers – MR conditional	Spring 2012
Parallel imaging made easy	Spring 2012
Radiotherapy planning – is MRI necessary?	Autumn 2012
Renal MRA – non-contrast	Autumn 2011
Spatial encoding – Part 1 - Slice selection	Autumn 2012

Happy reading!

David Reed

2012 BAMRR Conference - Leicester

by ***Helen Estall***

The of The Annual BAMRR Conference was held in Leicester on Saturday 6th October last year and over 100 delegates arrived in sunshine at the Mercure Hotel for a day of interesting talks, lunch and a catch up with MRI friends and colleagues.

The theme of this year's ISMRM/The morning session, chaired by Sharon Conway, outgoing President, started with a fascinating and quite scary talk by Steve Ross from Hampshire hospitals on his first-hand experience of suffering a fire in a MRI unit. The speed with which the fire spread ' two minutes from the staff and patient leaving the room until the ceiling was engulfed in flames' really pointed out the necessity of us all having regular fire practices. He also mentioned some very important points about the positioning of the quench button and fire proofing the wires to the quench button amongst other things.

Jill Mckenna from the N. Centre for Cancer Care in Newcastle, then gave an interesting talk on the use of MRI in radiotherapy. This centre is using a combination of both CT and MRI for radiotherapy planning. The advantage of MRI being the ability to image in three planes with 3D imaging and multiplanar reconstruction improving the accuracy of planning and identifying the position of organs at risk.

The last talk before a well deserved coffee break was from Dr Suchi Gaba from Leicester. Dr Gaba spoke on the role of MRI in imaging bone marrow disorders. This started with a revision of the different types of bone marrow and where they were located. MRI sequences were discussed along with normal and abnormal appearances and some examples of pathologies that can cause the changes.

After coffee and biscuits, Dr Jyoti Parikh from Guys and St Thomas' Hospital then spoke about the imaging of the recently news worthy PIP breast implants. Some Trusts had agreed to scan patients that had previously had these implants to look for evidence of a rupture. Examples were given of the different appearances of intra-capsular, sub-capsular and extra-capsular rupture and the complex cases of silicon adenitis.

Jenny Boyd-Ellison from Edinburgh then talked about incidental findings in the brain which was a research project funded by the BAMRR research grant. This talk highlighted the fact that when scanning patients you often come across incidental findings and she described her experiences with this process from whether it should be reported to informing the referrer and the patient.

Jelena Jovanovik from Eashing, Godalming Fitzpatrick Referrals then talked on the imaging of small animals in an emergency situation. She described the ways that they had to adapt their scanning techniques to gain accurate imaging information from a wide range of animal sizes, shapes and anatomy.

The final speaker before lunch was Julia Bigley from Sheffield, who gave a personal perspective on the very daunting prospect of passing the Health and Care Professions Council Audit. Julia gave some very useful advice on the requirements for the profile, ideas on how to set out the information, what different types of learning can be suitable and information about the personal statement.

The AGM for BAMRR members gave information regarding finance and membership and the new web site which was to be launched in November. It was then time for a hot lunch with friends and colleagues, a chance to chat to representatives from a wide range of manufacturers and to take a closer look at the posters.

The afternoon session chaired by new BAMRR President Janine Sparkes began with a talk from Adrian Thomas from Siemens explaining the design behind and process for producing superconducting magnets. He discussed the potential shortage of helium and the research involved in an alternative cooling agent.

Dr john Morlese from Leicester then gave a very informative and interesting talk on Radiological signs in neuro imaging including some pathognomonic signs and interestingly named ones such as the 'hummingbird' and the 'hot cross bun'.

Health and safety inspection was the next talk by Professor Barrie Condon in which he demonstrated the importance of documentation being available, accurate and up to date.

Dr Mark Horsfield again from Leicester then spoke about the physics of dynamic contrast in MRI followed by Matthew Benbow from Bournemouth with a thought provoking talk about 'button pushing' and the pros and cons of automated scanning software.

The last talk of the day was from Celia O'Meara from University College London about her first hand experience using PET MRI. This relatively new combination of modalities has many different safety considerations compared to MRI alone and is still only available in a couple of centres.

Next years conference will be on Saturday 5th October in Bristol so make a note in your diary now!

◆ **The Captivated Audience**

◆ **A Well Earned Lunch Break**

◆ **Sharon Conway, Outgoing President thanks Speaker Jelena Jovanovich**

◆ **Judging the Posters,**

◆ **Adrian Thomas speaks of the Design and Production of Superconducting Magnets**

Conference 2012 Evaluation results

52 delegates chose to complete the evaluation forms, so thank you to those who gave us the opportunity to change the things you didn't like in time for Bristol in 2012 and to continue the things you did:

THIS IS A BRIEF SUMMARY OF THE 'GOOD' COMMENTS:

Not enough time for questions, which often adds Lovely/great/fantastic venue

One of the best set of speakers so far at BAMRR

Good range of topics

Well organised

Well done!

Inspired to record more CPD

High standard of venue, facilities and lectures

Very interesting day

Good location, easy to get to

Nice to sit at tables and have a hot meal

Relevant topics kept to 20-30 minute lectures

Good to have lectures from different disciplines - radiographer, physicist

Excellent study day

Most of the lectures pitched at the right level

Appropriate length of each talk

Many of the lectures were easy to understand
and relevant to my learning

Lectures were informative without being too complex

Positive comments were received regarding the following lectures:

Fire – Steve Ross

Small animals – Jelena Jovanovik

Neuro imaging – John Morlese

Magnet technology – Adrian Thomas

PIP implants - Jyoti Parikh

of practical advice for radiographers as in the wrist talk.

BRIEF SUMMARY OF 'ROOM FOR IMPROVEMENT' COMMENTS:

Some presentations were too long, would prefer 15 minute slots

Some of the talks were interesting but don't feel I have learned as much as from other study days

Disappointed there weren't more clinical topics

Shame about the problem with red not showing on the slides

Dynamic contrast lecture was a bit heavy

More cold drinks should be available

Banked or angled seating would be better

Shorter lunch break and afternoon tea break would be good

Advertising and programme availability were too late

Price needs to be reduced

Cost of car parking should be included

Handouts/CDs of lectures would be useful

Speaker information available and how/where to get further information if required

SUGGESTIONS FOR FUTURE TOPICS:

Some physics

Cardiac MRI/Intervention

MRI conditional pacemakers

Forensic MRI

Future developments/research/3T and above

Neo-natal MRI

Paediatric MRI

Pathological signs and appearances

MRI reporting

Liver/ GI/Gynae/Breast imaging

IAMs in paeds with cochlear implants

Haemorrhage in the brain over time

Diffusion imaging

Whole body MRI

MRI angiography and new sequences (TWIST/NATIVE etc)

MRI in the Olympics/Armed forces

History of MRI

Industrial MRI

Functional MRI

Dealing with obese/claustrophobic patients

Practical tips/techniques for specialist/unusual applications

Comparison of sequences from different manufacturers

Clinical aspects/pathologies

Compiled by Rachel Watt from delegate suggestions.

EU PAD UPDATE

Progress on the revision of EU Physical Agents Directive 2004/40/EC on Electromagnetic Fields is being made at a considerable speed under the capable hands of the Irish Presidency. Discussions have moved on, past those areas where consensus had already been reached, and onto areas of disparity. There is a general feeling that agreement can be secured on a final text within a matter of weeks, and in fact may already have been secured by the time you read this. HSE continue to engage throughout the process and will keep you informed of progress through your news pages as soon as we can.

FURTHER MRI COURSE

The one you have all been waiting for....

Saturday 29th and/or Sunday 30th June 2013

at the

Royal Bournemouth Hospital

details of how to enrol on the course programme to follow soon

www.bamrr.org

BAMRR Policy Board Members, Spring 2013

EFFECTIVE FROM OCTOBER 2012

PRESIDENT
Janine Sparkes
01639 862441
janine.sparkes@abm-tr.wales.nhs.uk

TREASURER
Rebecca Vosper
01480 363743
Rebecca.Vosper@hinchingbrooke.nhs.net

PAST PRESIDENT
Sharon Conway
02890 368466
s.conway@ulster.ac.uk

SECRETARY
Helen Estall
0116 258 7786
helen.estall@uhl-tr.nhs.uk

SOCIETY REPRESENTATIVE
Alexandra Lipton
020 7740 7230
alexL@sor.org

SAFETY REPRESENTATIVE
Amanda Brennan
020 718 83933
AmandaA.Brennan@gstt.nhs.uk

MEMBERSHIP SECRETARY
Rachel Watt
01224 554440
rachelwatt@nhs.net

EDUCATION/COURSE ORGANISER
Matthew Benbow
Tel 01202 704091
Matthew.Benbow@rbch.nhs.uk

WEBSITE CO-ORDINATOR
Richard Wenyika
01278 429094
rwenyika@alliance.co.uk

2ND WEBSITE CO-ORDINATOR/ BOARD MEMBER
Karyn Chappell
karyn.bamrr@gmail.com

NEWSLETTER EDITOR
David Reed
08454 222556
david.reed@glos.nhs.uk

MRAG COORDINATOR
Lynn Graham
02871 345171 Ext 3208
Carolyngraham.01@btinternet.com

BOARD MEMBER/ 2ND NEWSLETTER EDITOR
Jill McKenna
0191 2139206
Jill.McKenna@nuth.nhs.uk

Invitation to participate in:

Epi MRI

Without your help it will not be possible to accurately assess whether epidemiological research on radiographers and others routinely working with MRI systems can be conducted!

Feasibility study for the construction of a UK epidemiological cohort study to assess health effects in relation to routine work with MRI systems.

MRI has evolved into one of the most important medical diagnostic imaging modalities. Trends towards stronger magnets and more frequent scans have increased exposure of personnel routinely working with MRI systems in the healthcare, industry and research sectors. There is no evidence of any long term health effects related to working with MRI systems, but to date also no epidemiological studies have been carried out to specifically investigate whether such a link does exist (or not).

Funded by the Department of Health, the Centre for Occupational and Environmental Health based at the University of Manchester, in collaboration with King's College London, Imperial College Healthcare, the Institute of Occupational Medicine, the University of Birmingham and the Sir Peter Mansfield Magnetic Resonance Centre in Nottingham, is currently conducting a feasibility study to evaluate whether a study on long term health impacts of occupational exposure to electromagnetic fields could be done in the UK.

To assess whether data required for such a study would be available, we are looking for volunteers to complete a short online survey.

This online survey aims to collect general information from all MR departments in the UK on the type of MRI systems used, the number of people working with MRI in different facilities, and the availability of employment records. **This survey DOES NOT collect personal details or health related information of staff members and any information provided will be kept anonymous**. We will need the voluntary help of people, especially radiographers, routinely working with MRI systems to obtain valid information for this feasibility study.

We hope you are willing to complete the survey on behalf of your facility or institute.

Please click on the link below.

http://www.coeh.man.ac.uk/research/mri/mriQuestionnaire.php

For more information, please contact

Dr. Anna Molter via email
anna.molter@manchester.ac.uk
or phone
0161-2755691.

Identity Crisis

Helen Estall *Superintendent Radiographer, Leicester Royal infirmary*

An Unusual Adverse Event

In the MHRA 'One liners' from July 2011 (Issue 86), a 'Named and flamed' headline announced that there had been a recent report of an unusual adverse event in MRI involving a patient identification (ID) bracelet. It stated: 'Be aware that such bracelets may cause thermal burns and may need to be removed or padded to prevent direct contact with the patient's skin during all MRI examinations particularly if the patient is unable to communicate, eg requiring sedation or anaesthesia.'

After investigation, an article in Radiology from 2010 was found describing this event. It stated that an unique combination of factors involving a patient ID bracelet had led to a patient suffering third degree burns to their wrist, resulting in emergency surgery and long term therapy.

This particular patient was referred for MRI of the Lumbar spine, he was moderately obese (128kg with a BMI of 40), he was also severely claustrophobic for which he required a GA to undergo the scan. He was scanned head first, all contact points were padded as necessary and all monitoring cables were padded to avoid direct skin contact. The scan was undertaken on a 1.5T Philips Intera with an 8 channel spine coil. The scan was clinically uneventful and lasted 70 minutes. After recovery from the anaesthetic, the patient complained of severe pain under his id bracelet (a LB2;Laserband, St Louis, Mo) as well as pain over the index, middle and ring fingers. The bracelet was removed and an area of redness was noted underneath for which he was treated with iv pain relief with only partial success. He was then referred to the Emergency Department for further evaluation. At 2 hours after the end of the scan a 2x3cm blister was noted where the ID bracelet had been, the patient was also suffering with pain in the hand and wrist and numbness in the fingers over the median nerve distribution. The wrist was immobilised and the patient admitted for observation as the findings were consistent with an acute carpal tunnel syndrome with a wrist burn, if this progressed, it would need urgent decompression surgery. The following day, the carpal tunnel symptoms had worsened with elevated compartment pressure leading to an emergency carpal tunnel release and a volar fasciotomy of the right forearm. Intraoperative findings were significant and characteristic of an electrical burn injury (specifically to the median nerve). The patient underwent two repeated irrigation and debridement procedures of his forearm wound and the skin under the blister progressed to a deep third degree burn also requiring debridement. Eleven days after the injury, the open forearm wound was again debrided and closed with a skin graft. After discharge the patient underwent prolonged hand therapy and has had a gradual recovery of his median nerve and hand function.

The exact mechanism causing the injury in this case is unclear. No fault was found with the MR system, imaging protocol or coils, the patient's contact points were all padded and no leads etc were in the proximity to the injured limb. The blister appeared in the area under the barcode print of the ID bracelet and further investigation by the article authors revealed that the toner used to print the barcode contained 40-50% iron oxide. The article suggested that the snug placement of the band around the wrist, the patient's wrist anatomy and the addition of sweat created a conductive loop which in turn caused a flow of electrical current into the arm throughout the scan. Additional risk factors were the long acquisition time and possibly the location of the RF coil to the wrist. After this incident, the hospital Quality Assurance team recommended that ID bracelets were to be removed or padded for all patients requiring sedation or GA who were to have a MRI scan.

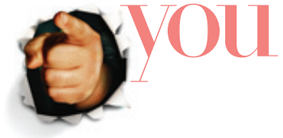
Burns have been described in connection with MRI in the past, this has been mainly linked to monitoring equipment, oxide-based tattoos and transdermal patches with metal components. The risk of excessive heating is related to the proximity of the RF coil to the patient's tissue as well as to the frequency and power of the RF used.

To prevent the possibility of a burn during MRI the following is advised (taken from mrisafety.com):

- Ensure that there are no unnecessary metallic objects contacting the patient's skin.
- Prepare the patient for the MR procedure by using appropriate padding to prevent skin-to-skin contact points and the formation of "closed-loops" from touching body parts.
- Insulating material (minimum recommended thickness 1cm) should be placed between the patient's skin and the transmit RF coil (alternatively, the transmit RF coil itself should be padded).
- Use only electrically conductive devices, equipment, accessories (e.g., ECG leads, electrodes, etc.), and materials that have been thoroughly tested and determined to be safe for MR procedures.
- Carefully follow specific MR safety criteria and recommendations for implants made from electrically-conductive materials (e.g., bone fusion stimulators, neurostimulation systems, cardiac pacemakers, cochlear implants, etc.).
- Before using electrical equipment, check the integrity of the insulation and/or housing of all components including surface RF coils, monitoring leads, cables, and wires. Preventive maintenance should be practiced routinely for such equipment.
- Remove all non-essential electrically conductive materials from the MR system (i.e., unused surface RF coils, ECG leads, EEG leads, cables, wires, etc.).
- Keep electrically conductive materials that must remain in the MR system from directly contacting the patient by placing thermal and/or electrical insulation between the conductive material and the patient.
- Position electrically conductive materials to prevent "cross points". A cross point is the point where a cable crosses another cable, where a cable loops across itself, or where a cable touches either the patient or sides of the transmit RF coil more than once.
- Position electrically conductive materials to exit down the centre of the MR system (i.e., not along the side of the MR system or close to the transmit RF body coil or other transmit RF coil).
- Do not position electrically conductive materials across an external metallic prosthesis (e.g., external fixation device, cervical fixation device, etc.) or similar device that is in direct contact with the patient.
- Allow only properly trained individuals to operate devices (e.g., monitoring equipment) in the MR environment.
- Closely monitor the patient during the MR procedure. If the patient reports sensations of heating or other unusual sensation, discontinue the MR procedure immediately and perform a thorough assessment of the situation.

The LB2;Laserband, St Louis, Mo is no longer in production and some manufacturers provide a statement regarding the MRI safety of their ID bracelets, such as Zebra Technologies.

Link to article: http://radiology.rsna.org/content/254/3/846.full



We are constantly looking for members for the BAMRR board, so if you feel you would like to join us in promoting MR safety and education – and, of course, helping to organise our annual conference – then please contact any member of the policy board.

Making HASTE: Challenging tradition

Cantlay, N; Bury, R; Cotton, A - Direct Medical Imaging, St.Annes, Lancashire

Introduction

Flexion/extension examinations are commonly requested to assess the stability of the lumbar vertebrae. Rotation between adjacent vertebrae and translation in a dorsoventral direction are often considered and deduced mathematically from radiographic images. The latter, however, can be prone to positioning errors which create geometric unsharpness and affect calculations. Lateral lumbar radiography is also associated with high doses of ionising radiation and poor visibility of the L5/S1 disc space. This study considers the use of flexion/ extension HASTE sequences as a safe, quick and cost-effective alternative to supplementary flexion/extension radiographs requested in conjunction with routine MRI examinations of the lumbar spine.

Method

The authors imaged two 60-year-old female patients suffering from lower back pain and two asymptomatic volunteers (one 42-year-old male and one 53-year-old female) using a Siemens Magnetom C! Open field (0.35T) scanner12. After a routine lumbar spine protocol (patients only), additional flexion/extension HASTE sequences were acquired with the subjects prone (figure 1). This took approximately five minutes per subject, including positioning: each sequence comprised three 5mm sagittal slices with a total scan time of 56 seconds. The range of motion between flexion and extension was calculated using Cobb angles.

Results

The patients achieved a range of motion between 30º and 40º (figures 2 and 3) and the volunteers between 35º and 50º (figures 4 and 5). The patient with the lowest range of motion had an above average BMI, while all the others were within normal limits. Both patients and volunteers found the positioning relatively comfortable and easy to maintain for the duration of the HASTE sequences. The range of motion was comparable with previous studies[1,2]. The inclusion of symptomatic patients in this study, however, shows that dynamic lumbar spine imaging using MRI is a viable alternative to plain film imaging in the clinical setting.

Conclusion

Erect MRI imaging has more advantages than supine or prone imaging: ease of patient positioning, better detection of mobile spinal instability and improved detection of disc herniations. However, dynamic horizontal imaging can demonstrate changes in inter segmental motion that may correlate with clinical symptoms of lower back pain, whereas static horizontal imaging cannot. Unfortunately, upright MRI scanners are relatively rare, with approximately 150 worldwide and only two in the UK. Open field horizontal scanners are relatively more common, and for the purposes of providing similar information to that obtained from fexion/extension radiographs, but without the use of ionising radiation, they may be an under used resource.

Figure 1: Asymptomatic volunteer positioned for (A) flexion (coil removed) and (B) extension (coil in place) lumbar spine HASTE imaging using a Siemens Magnetom C! open field MRI scanner.

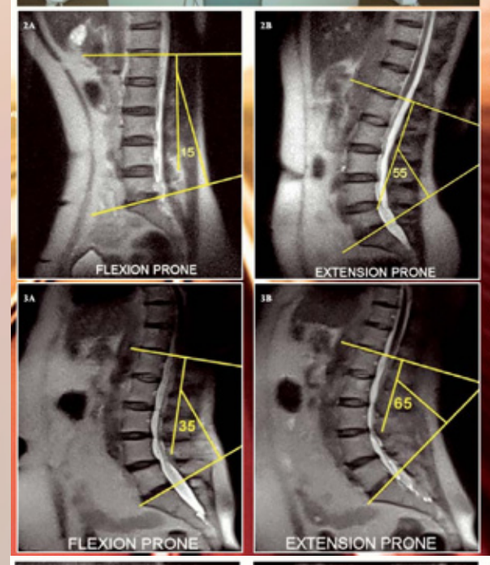


Figure 2: HASTE images showing COBB angles for a symptomatic patient with average BMI undergoing (A) flexion and (B) extension lumbar spine MRI (range of motion 40º).

Figure 3: HASTE images showing COBB angles for a symptomatic patient with above average BMI undergoing (A) flexion and (B) extension lumbar spine MRI (range of motion 30º).

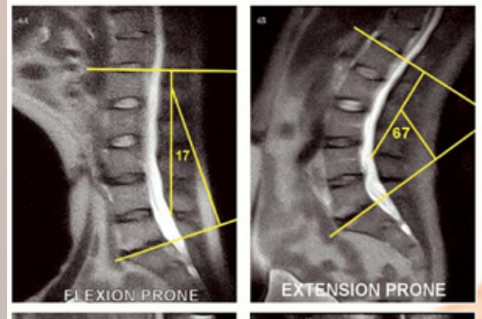


Figure 4: HASTE images showing COBB angles for an asymptomatic male volunteer undergoing (A) flexion and (B) extension lumbar spine MRI (range of motion 50º).

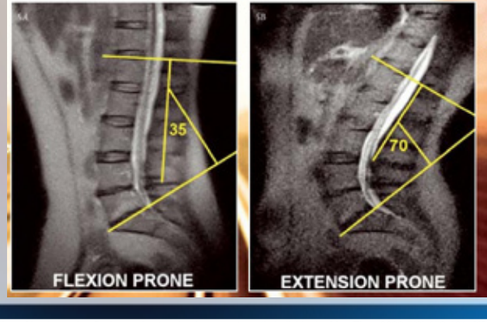


Figure 5: HASTE images showing COBB angles for an asymptomatic female volunteer undergoing (A) flexion and (B) extension lumbar spine MRI (range of motion 35º).

References: [1] Edmondston S, Song S, Bricknell R, Davies P, Fersum K, Humphries P, et al. MRI evaluation of lumbar spine flexion and extension in asymptomatic individuals. Man.Ther. 2000;5(3):158-164; [2] Harvey SB, Smith FW, Hukins DWL. Measurement of lumbar spine flexionextension using a low-field open-magnet magnetic resonance scanner. Invest.Radiol. 1998;33(8):439.

***About the Authors**: Dr Nick Cantlay Bsc (Hons) Ph.D, Dr Roger W Bury Bsc (Hons) MB. ChB FRCR, & Mrs Anne Cotton DCR(R) are part of the diagnostic medical imaging team at Direct Medical Imaging.*

AN OVERVIEW OF SINGLE VOXEL MAGNETIC RESONANCE SPECTROSCOPY USING A POINT RESOLVED SEQUENCE AND ITS APPLICATION IN LOW GRADE GLIOMAS

Deborah Jarvis BSc (Hons) Diagnostic Radiography

The University Of Sheffield.

INTRODUCTION

Magnetic Resonance Spectroscopy (MRS) allows the chemical make up of the brain in vivo to be assessed by measuring concentrations of metabolites. Single voxel Point Resolved Spectroscopy is a time efficient technique which assesses brain pathology alongside magnetic resonance imaging (MRI)

MR SPECTROSCOPY

Protons from the ^1H nucleus resonate at different frequencies relative to the applied magnetic field B_0 because of their chemical structure. Molecules with different numbers of ^1H protons have their own unique resonant frequency due to its own electron environment. This occurs because protons within each molecule are affected by electron clouds of neighbouring atoms which induces an opposing magnetic field and lowers the B_0 magnetic field they would be normally exposed to. This creates a chemical shift between each molecule which is considered an artefact in MRI but provides the only source of variation in the magnetic field in MRS.
Spins of neighbouring molecules also interact with each other affecting the local magnetic field around each nucleus. This causes a single peak to be divided into a complex peak (doublet, triplet, multiplet) and is known as spin-spin coupling or J coupling.
The chemical shift between each molecule is very small and expressed in parts per million (ppm), a value independent of magnetic field strength.

THE METABOLITES

Many brain metabolites can be identified using MRS including:-

•Lipids (Lip) 0.9, 1.4ppm -Correlate to the extent of tissue necrosis, can also be result of voxel contamination .

•Lactate (Lac) 1.35ppm – Seen as a doublet peak. Produced by anaerobic metabolism indicating hypoxia and macrophagic invasion. Not usually detected in healthy brain.

•N-acetyl aspartate (NAA) 2.02, 2.6ppm - Usually highest peak on the spectrum in normal brain A free amino acid found in neurons, a marker of neuron integrity. Decrease corresponds to neuron death or the replacement of healthy neurons by other cells such as tumours.

•Glutamine and Glutamate complex (Glx) 2.1, 2.5ppm - Involved in excitatory and inhibitory neurotransmission.

•Choline (Cho) 3.2ppm – involved in cell membrane metabolism and increases whenever there is cell membrane inflammation, proliferation or demyelination.

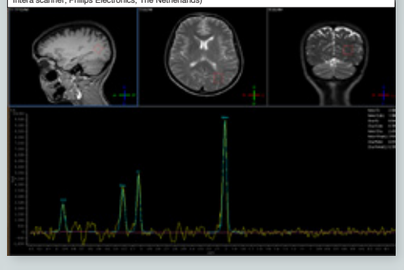
•Creatine and Phosphocreatine (Cr and Cr2) 3.02, 3.9 ppm - Marker of cell energy metabolism, involved in detoxification and regulation of neurotransmission. Indicator of overall cellular density often used as internal reference for metabolic changes of other metabolites.

•Myo-inositol. (ml) 3.6ppm – A sugar only present in glial cells. It increases in cases of glial proliferation or decreaseswith specific suffering of these cells.

THE MAGNETIC RESONANCE SPECTRUM

The results of different metabolites can be displayed either as grey scale images or a spectrum as seen in Figure 1.

Figure 1. MR spectrum with localising images demonstrating position of voxel and peak positions (Base hospital 2010). PRESS sequence using TE 144, TR 1600, NSA 256, voxel 15x15x15mm (Philips 3Tesla Intera scanner, Philips Electronics, The Netherlands)



SPECTRUM AND PEAK PROPERTIES:

The spectrum is displayed on the horizontal axis and reads from right to left. Zero corresponds to a chemical standard insensitive to fluctuations in temperature or pH (For ^1H the standard is trimethylsilane, TMS). Most metabolites of interest lie in the narrow range of frequencies between 0 and water at 4.7 ppm. The vertical Axis- height of peaks is in arbitrary units due to scaling factors e.g. sensitivity of the coil, preamplifier.
Each peak has certain properties:

Peak position: metabolites identified by their unique resonance frequency in ppm on the horizontal scale, a value which is constant regardless of B_0.

Peak width: typically full-width at half-maximum height (FWHM), relates to the metabolites particular environment

Peak area: directly proportional to the number of spins producing the signal, relates to the concentration of the metabolite. Changes according to disease processes

SPECTRAL QUALITY

The quality of the resultant spectrum depends on several criteria:-

Signal to noise (SNR) = Height of metabolic peaks in relation to baseline noise. Larger voxel size, higher echo and repetition times and increasing number of acquisitions all improve SNR

Spectral resolution = Peak width and separation.
Field strength, field homogeneity, adequate water suppression and avoidance of lipid contamination are all important factors affecting spectral resolution.

Field Homogeneity
Metabolites have very small chemical shift values over a narrow range of frequencies, therefore B_0 field homogeneity is critical . High order shimming, where currents flowing through shim coils are adjusted by automated shimming procedures, unify B_0 so that it is constant. Field homogeneity requires a chemical shift of less than 0.07ppm over the volume for adequate resolution of each peak,

Water and Lipid suppression
The signal from water and lipids if not reduced significantly would make metabolite peaks invisible if displayed on the same spectrum. The signal from lipids in brain MRS is avoided by placement of the voxel away from the scalp and orbital region. Lipid contamination from outside the volume of interest can also be reduced by spatial saturation.
Water suppression can be achieved with various techniques but the most common is **Che**mical **S**hift **S**elective (CHESS) RF pulse applied at the Larmour frequency of water followed by spoiler gradients to destroy the transverse magnetisation water signal.

SINGLE VOXEL SPECTROSCOPY

Single Voxel Spectroscopy (SVS) measures the signal from a small volume of tissue defined by three orthoganal intersecting selective RF pulses (Figure 2).

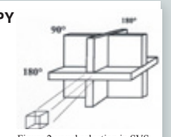


Figure 2 voxel selection in SVS

SVS Advantages;
•Specific Voxel placement to assess pathology possible
•Uses both short and long echo times
•Relatively fast acquisition time
•Achieves greater homogeneous water suppression.
SVS Disadvantages
•To measure multiple areas subsequent measurements must be made.
•The area of measurement may extend beyond the visible voxel and if the area of interest is close to an area with high magnetic susceptibility e.g. CSF and scalp, may result in distorted or unidentifiable spectra

PULSE SEQUENCES FOR SVS.

The two main sequences for SVS are **P**oint **Res**olved **S**pectroscopy (PRESS) and **STI**muled **E**cho **A**quisition **M**ode (STEAM). Although there are advantages to each, PRESS is used due to its better SNR.

PRESS SEQUENCE.

This pulse sequence diagram is shown in Figure 3.

The sequence starts with the CHESS pulse suppressing water signal. Three intersecting orthogonal planes are excited in turn by slice selective RF pulses.

The first slice selected by gradient G_x excited by a frequency selective 90º RF pulse

↓

A gradient reverses dephasing which occurs during excitation producing a FID signal.

↓

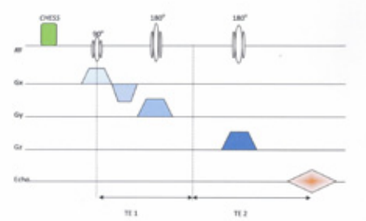
Second selective 180º RF pulse excites second slice defined by gradient G_y at time TE1. Intersecting slabs of first and second slices rephrased by this 180 pulse and form an echo at time TE1 after the 90º pulse, which is not sampled.

↓

Gradient G_z selects the third slice using another 180 RF pulse to produce a final echo at T2. the net magnetisation from the intersecting volume of all three slices is sampled to produce the spectrum.

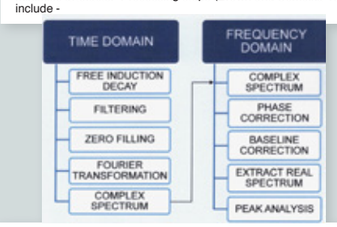
Crusher gradients (not shown) either side of the 180 pulses define the volume selected so that only spins in the volume experiencing all three RF pulses contribute to the final signal. They also dephase unwanted stimulated echoes and FID signals. A read out gradient is not used to provide spatial or positional information but the frequency information is used to identify each molecule.

Figure 3 PRESS pulse sequence Diagram



SIGNAL PROCESSING

^1H MRS requires no additional hardware but automated manufacturer software to process the spectral frequencies. This is necessary to improve both SNR and Spectral resolution and minimise artefacts. Processing steps (Brown and Semelka 1999) include -



AQUISITION PARAMETERS

Sequence choice and timing parameters determine height of metabolite peaks The signal from the metabolites should be maximised by selecting a TE and TR to avoid signal loss due to T1 relaxation and T2 decay. A long TR (1500+ms) should be selected to minimise signal loss due to T1 relaxation. The echo time between excitation and measurement (TE) determines which metabolites can be observed. Different molecules decay at different rates, therefore the height of metabolic peaks are altered when acquiring spectra at different TE's If the T2 relaxation time of the metabolite of interest is short then the TE selected must be kept short (30ms) to detect the signal before T2 decay is complete.(McLean and Cross 2009)

Receiver bandwidth is chosen wide enough to detect all spectral frequencies but narrow enough to minimise noise contribution to the image. This limits the number of digitization points, therefore In order to improve spectral resolution zero filling is employed at the end of the FID.
The number of acquisitions is relatively high in MRS to ensure adequate signal as the size of the voxel and consequently tissue, is relatively small.
Whatever parameters are chosen consistency is vital to ensure the resulting spectrum are comparable to a normal reference spectrum.

Clinical Application of MRS

MRS measures metabolite concentrations and consequently offers the possibility to 'visualise' the chemical environment of the brain. When used in conjunction with structural imaging it can clarify ambiguous findings.,
One specific application of MRS is to assess and monitor patients with low grade gliomas (LGG) Grading of gliomas is essential to identify best treatment and prognosis as surgical resection, chemotherapy or radiotherapy are usually delayed until tumour progression as intervention carries significant risks (Romanowski et al 2008). SVS can specifically analyse Glioma area to determine metabolite concentrations which can be compared in serial imaging to detect tumour progression. Metabolite ratios are determined by using one peak in the spectrum as a reference and changes in ratios used to determine normal and pathological tissue.
MRS features of gliomas include:-
•Reduced concentrations of NAA - lower in high grade than LGG (Cao, Sundgren et al 2006)
•Increased concentrations of Choline - greater in high than LGG (Al-Okaili, Krejza, et al 2006)
•Reduced concentrations of Cr and Cr2 (Cao, Sundgren et al 2006)
•Increased ratios of Cho/Cr (Griffin and Kauppinen 2007)

Comparing Figure 1 and Figure 4 and from the table below it can be seen how changes in metabolite concentrations was used to help identify metastatic transformation of a low grade glioma in a 40 year old patient. As a result of the changes in concentrations and as a result of MRI the patient underwent successful surgical resection and tumour progression was confirmed by histopathalogical. analysis.

Metabolite And ratios	Concentration at Low Grade	Concentration at High grade	Ratios at Low Grade	Ratios at High Grade
NAA	170.5	145.2		
Cho	495.5	548.1		
Cr	257.3	205.4		
Cr2	160.3	110.7		
Cho/Cr Normal= <1			1.9	2.6

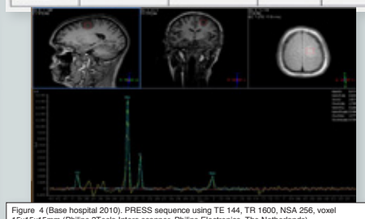


Figure 4 (Base hospital 2010). PRESS sequence using TE 144, TR 1600, NSA 256, voxel 15x15x15mm (Philips 3Tesla Intera scanner, Philips Electronics, The Netherlands)

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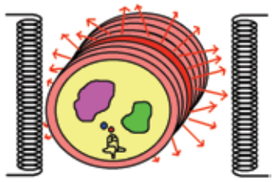
Spatial Encoding
Part 2 – Phase Encoding

Matthew Benbow *Superintendent Radiographer Royal Bournemouth Hospital*

Introduction

For any medical imaging modality it is necessary for the receiving device to display the output in an order that correlates to the patient's anatomy, i.e. that the resultant image represents the patient.

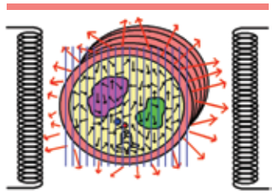
With plain radiography and Nuclear Medicine, the patient is positioned directly in front of the receiving device, and therefore the anatomy is projected directly into a corresponding position to that found in vivo. With Ultrasound, the signals are reflected back to the transducer, but remain in their true anatomical positions. Even though in CT the detectors rotate, at any given time in this rotation the anatomy is being mapped such that the reconstruction system can create a true image. MRI however is different.



◆ **Image 1**

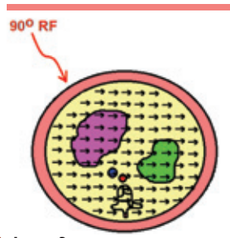
Signals from our excited slice of interest are detected in our receive coils and a current is generated. But in order that an image can be made, it needs to be established from exactly where in this slice each signal has originated. To achieve this, each signal must be in some way 'tagged' with this extra spatial information. In our example we are considering an axial image, so if we can gain the x and y coordinates of each signal, then a meaningful and accurate image can be resolved.

The first part of this process will be to reduce things to a one dimensional problem by establishing which column the signal comes from, and this is done by a process called Phase Encoding.



◆ **Image 2**

In this example we will use phase encoding to establish which column the signals are originating, i.e. where in the x direction of the slice. As an operator you can easily alter this to get the phase encoding process to establish rows, i.e. where in the y direction, by swapping the 'Phase Direction' within your scanning parameters. There are several good reasons that you may need to do this, but they will not be discussed in this article. For now let's stick with using phase encoding to establish the x axis position.

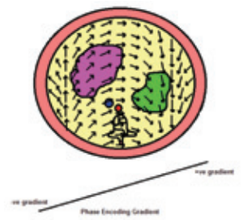


◆ **Image 3**

To help make the description of phase encoding easier to understand, we will apply it to spin echo imaging . When the initial 90° RF pulse is introduced to the patient, two important processes occur. Firstly the protons are moved into a higher energy state. This is important to us as this enables them to release energy on removal of the RF as they return to their preferred state of precession, and consequently produce a signal that we can measure. Secondly, they are momentarily all aligned in the same phase of their precessions.

Fortunately this phase information is carried within the signal received by the coil, so we can exploit this to enable phase encoding.

To phase encode the protons, just after the 90° RF pulse has been switched off, a gradient is applied (in our example in the x direction) for just a few milliseconds, then switched off again.



◆ **Image 4**

This gradient adds to the main magnetic field such that is becomes momentarily slightly weaker at one side of the imaging plane and stronger at the other. The result is that protons experiencing a higher magnetic field will spin faster than those in the lower field for the period of time that the gradient is on. This causes the once aligned protons to fan out, based on where they are along the phase gradient. Once the gradient is switched off all the protons revert to precessing at the larmor frequency, but they will retain the acquired phase shift, and as such they will be phase encoded, i.e. protons within each column will share the same phase, but across the patient each column will differ in phase from the others in a predictable way. Therefore, by considering the phase of a signal measured in the receive coil, the scanner is able to establish from which column of the patient it originated.

The net result of this is that, for example, if a signal is measured with phase ↗ then you would be able to say that is must have originated from somewhere in the 5th column from the left in the diagram, however without more information you cannot yet tell from which row. Once we have this information, then we could fully resolve the location of this signal and use it to form an image, but for this we need to turn to the final process of spatial encoding which will be covered next time in part 3.

Phase Encoding and Scan Time

With a simple spin echo sequence a single TR produces one phase encoding step and therefore fills one line of k space. Multiple TRs need to be repeated for each line of resolution chosen.

Higher phase resolution = more phase encodings

More phase encodings = higher number of TRs

Higher number of TRs = More lines of k space to be filled

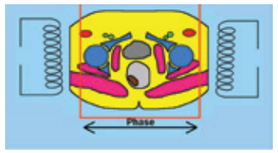
More lines of k space to be filled = Longer scan time

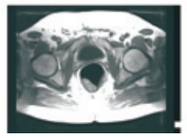
Therefore your chosen image resolution in the phase direction α Scan time

With fast spin echo, several lines of k space are filled in each TR, and so scan times can be significantly reduced.

To help keep scan times low, the phase and frequency directions are usually chosen so that phase encoding covers the narrowest part of the patient's anatomy wherever possible. This technique will therefore keep scan the time as short as possible as increasing frequency encoding does not affect scan time. This will be discussed further in the next issue.

Phase Wrap



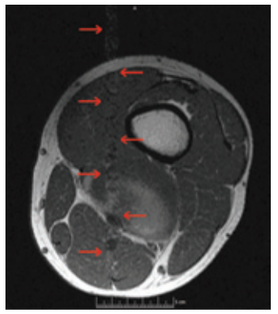


◆ **Image 5**

If the field of view coverage in the phase direction is close to (or even within) the patient's anatomy (red box in the diagram), there is a good chance that phase wrap will occur. This is because despite this tissue being outside of the field of view and hence area of interest, it will still have received excitation and phase encoding. The phase these areas are put into will match areas of interest on the other side of the patient in the phase direction, and therefore the scanner software merely follows the encoding rules and maps them into the image where it believes they belong. There are several options to prevent phase wrap. Ensuring the field of view is larger than the anatomy in the phase direction is one option, which may involve swapping the phase and frequency direction as described above. Another option is to use pre-saturation bands to obliterate the areas of anatomy that may wrap, such that when they do, they produce no signal. Probably the most common option is to add phase oversampling or anti-aliasing into the sequence. This adds phase encodings beyond the field of view in the phase direction to ensure any phase wrap occurs in areas that will ultimately lie outside of the field of view and not be seen. This does however increase the overall scan time.

Parallel Imaging

Parallel imaging is used extensively in modern MRI to help reduce scan times. The field of view in the phase direction is purposely reduced to keep the number of phase encodings (and hence scan time) to a minimum.



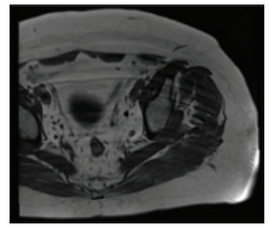
◆ **Image 6**

As we have just considered, this would normally result in phase wrap, but by use of a short reference scan before the main acquisition, the scanner can determine which tissue is real and which is wrapped, and eliminate the unwanted signals from the image.

Phase Mismapping

Some anatomy is prone to movement, e.g. the anterior abdomen from respiration, the beating heart, peristaltic bowel, CSF flow or flow in a vessel. Where anatomy moves between application of the phase encoding gradients it can be mismapped into the final image and artefacts occur such as the popliteal flow artefact in Image 6 and the multiple anterior abdomen respiratory artefacts in image 7.

Sometimes swapping the phase and frequency encoding directions can help. Whilst it will not eliminate the artefact, it can project it into a less obtrusive location. Saturation bands can also be placed over moving anatomy outside of the area of interest. This is a vast subject and will therefore not be covered in any further detail in this article.



◆ **Image 7**

3D Imaging

With 3D sequences, the whole volume of interest within the patient is excited at the same time, i.e. the process of slice selection described in the last issue does not take place. Instead, slice selection is performed with a second phase encoding step. Because of this, aliasing is also able to occur in the slice direction which is known as slice-wrap. This can be seen in the first few and last few slices of a 3D volume. It can be eliminated by adding some slice oversampling, at the cost of a small amount of scan time.

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