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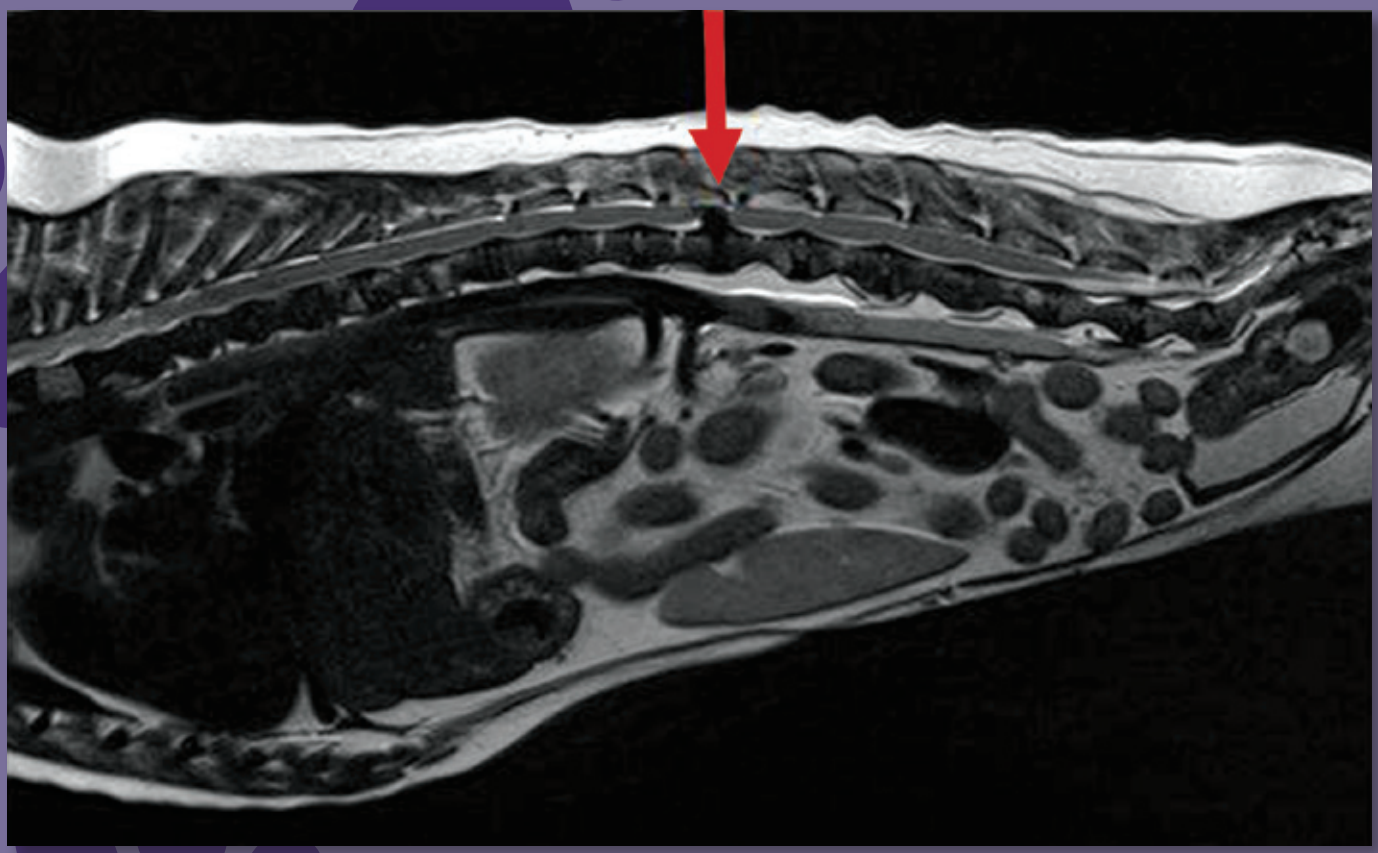
BAMRR

news

THE NEWSLETTER OF THE BRITISH ASSOCIATION OF MR RADIOGRAPHERS



PET SUBJECT

SPINAL EMERGENCIES IN COMPANION ANIMALS

BRISTOL CONFERENCE
FULL REPORT

IDENTITY CRISIS
PROBLEMS WITH INK

welcome from your BAMRR PRESIDENT

Welcome to the autumn newsletter.

Two long serving policy board members are leaving us. Lynn Graham who is a BAMRR past president is leaving and moving on to become chair of the MR advisory group of the SOR. Amanda Brennan who has been our safety representative over the last few years is also leaving. They have both given their time freely to the education of MR radiographers and we wish them success in the future.

We have four new policy board members who will introduce themselves in the newsletter. Many of the policy board roles have changed in October so please check the website for the updated roles.

BAMRR ran a successful session at UKRC in Liverpool this year which focused mainly on advances in MRI. This was followed by a successful 30th annual conference which took place in Bristol in October. BAMRR would like to thank all the speakers for their excellent contribution to the day. A full conference report is available in the newsletter.

The conference would not be possible without the continued support of the sponsors. BAMRR was lucky enough to secure three platinum sponsors this year in Guerbet, GE and Bayer.

BAMRR "further" course was due to run earlier this year however it was felt that the course content needed to be updated to reflect new developments in MRI. For this reason plus the unavailability of certain key speakers meant the course was postponed. The updated course is set to run next spring.

BAMRR has been actively involved with the SOR in updating the " Safety Guidelines in MRI". This document is due to be released early next year and will be a valuable source of information for MR radiographers.

The new BAMRR website was launched this time last year. The board has had to put a lot of work into the infrastructure of the website to improve its functionality. If you experience any issues with the website please contact us so we can attempt to resolve the issue.

It has been another busy year for the policy board and I would like to thank them for all their hard work and support.

Janine Sparkes

from your EDITOR

Hello and welcome to the Autumn/Winter Newsletter which is packed full of interesting articles.

Many thanks to David Reed for all his hard work and I wish him well in his new role as BAMRR Treasurer. I am looking forward to my new role as newsletter editor and would like to remind you all we would love to here from you. In this era of improving patient experience and efficiency of MR machines the magazine is a platform for you our members to disseminate information to the wider MR community please send articles to me jill.mckenna@nuth.nhs.uk

My background is as a diagnostic radiographer in MRI although I now work within a radiotherapy department. I thought it was worth mentioning a new development at a recent European congress in Geneva, the future of MRI within radiotherapy was highlighted with a research consortium now established on MR-guided radiation therapy developing the first prototype of an integrated MRI scanner and radiotherapy machine due to become clinical in 2017.

In this edition read about the conference in Bristol which covered a very diverse range of topics from the history of MR to the latest advancements. The 31st Annual conference next year will take place in my home town of Newcastle upon Tyne I look forward to welcoming you all.

Happy reading !!!!

2013 BAMRR Conference - Bristol

This year's annual BAMRR conference was held on Saturday 5th October at the Royal Marriott hotel in Bristol.

The day was chaired by BAMRR President Janine Sparkes and Past President Sharon Conway. After coffee and Danish pastries, the day started with a talk by Chris Lawton, Superintendent Cardiac Radiographer from the Research unit at the Bristol Heart Institute on stress perfusion. This unit receives between 60 and 200 referrals per month which, Chris believes that Cardiac MRI is the fastest growing area of MRI at the moment. He went through the process for stress perfusion including the importance of patient preparation, one radiologist apparently tells patients they will have a feeling of 'impending doom' and showed some very interesting images.

The second lecture was entitled 'MRI in the witness box' by Dr Neil Stoodley, a Consultant Neuroradiologist from Bristol. Dr Stoodley started his talk with amusing comparisons between the working life of a lawyer and a radiologist, he went through the importance of MRI in cases of non-accidental head injury and the importance of scanning the whole spine as well as the head.

The final lecture before coffee was an interesting and useful update on implant safety by Dr Donald McRobbie and Denise Newsom from Imperial College and Eden Learning respectively. They went through the 3 different aspects of how conditional implants need to be checked and made it clear that each site needs to know what the maximum fringe field gradient is for each scanner. Also, the importance of obtaining a field map from the manufacturers.

After more coffee and cakes, the morning session resumed with a talk on whole body MRI in oncology by James Stirling, Research Superintendent at the Paul Strickland centre. Whole body MRI is becoming much more common place and he gave a mainly non-physics explanation of DWI, the sequences that they use and tips for dealing with the most common artefacts.

Professor Ian Young OBE then gave a fascinating talk on the history of MRI. The first T1 and T2 measures were in the mid 1950s with the first clinical image of the 'Aberdeen mouse' in 1974. The original field strength was 0.1T with 10mT/M. Professor Young then showed us the first clinical image of a brain from 1978 and stated that there have been no new clinical sequences for different tissue contrast since 1986.

The last lecture of the morning session was from Dr John Morlese, back by popular demand. Dr Morlese is a Consultant Neuroradiologist from Leicester and talked about the appearances of cerebral haemorrhage on MRI over time and how location gives an indication of the disease process involved.

The AGM was well attended with a brief overview of membership figures and the treasurer's report. Lunch was a hot buffet in the hotel restaurant with plenty of time to view the posters and sponsors tables.

The afternoon session started with an update on the EMF Directive by Professor Stephen Keevil from Guy's and St Thomas'. He summarised the history of the directive, the issues involved with this for MRI in particular and what had been achieved since 2004, including details of the derogation for MRI. The new directive was adopted this year with a transposition deadline of July 2016 and a non-binding 'practical guide' will be published to help us work out what is required.

The last invited speaker was Dr David Collins from the Institute of cancer Research in Sutton who spoke on the physics of whole body diffusion. He explained what it is, how we measure it and what we are measuring. He also stated that protocol optimisation by a physicist and QA were essential.

The first of the three proffered papers was presented by Sanjay Devji, an audit on the impact of monitoring with Liver MRI-R2 on liver iron burden done at Whittington hospital in London. The second paper presented jointly by Daren Walls and Bianca Lottmann from City University and Royal Free, London was on the impact of performing MRI under natural sleep on the inner ears of newborn infants. This paper won the proffered paper prize. The final paper was presented by Ann Briody from King's College Hospital, London. Ann presented a paper on the role of MRI in the pre-operative assessment of rectal cancer.

The poster prize was presented at the end of the afternoon session, and went to Catherine Mills from Preston for her poster on 'Considering changing practice to scan patients with MR conditional pacemakers? Then consider this…'.

Next years conference will be in Newcastle upon Tyne and we look forward to seeing you there!

◆ **Chris Lawton - MRI Cardiac Superintendent from University Hospitals Bristol**

◆ **Dr Neil Stoodley - Consultant Paediatric Radiologist from North Bristol NHS Trust**

◆ **Janine Sparkes, BAMRR President, Sharon Conway, Past President**

◆ **Cofee Time Out**

New BAMRR Board member

◆ **Paola Griffiths**

I am currently based at Swansea University, working on clinical trials and pure research as a Supt research radiographer.

I have had a keen interest in all aspects of MRI and have working on GE and Siemens scanners. I started my MRI journey in Oxford, learning the basics and hands on sessions then move to South Wales to pursue MRI full time, and to assist in the set up a new service. Here I was able to studying and gained my Pgd in MRI at Lancaster University, a mind broadening experience.

I have also worked aboard in Italy providing application training to New MRI technicians in Italian which was both enjoyable and challenging.

Moving to Alliance Medical I assisted with the training and development of new staff and skills, and facilitated the practical and theoretical training program, ran study days and regularly presented.

Now based at Swansea University, I am expanding in to the field of MRI and medical research, looked at collaborations and clinical research trials. Here I completed further studies of a MA in Education Leadership and Management at Newport University.

I am hoping that I can bring to BAMRR my experience and skills to help the society grow from strength to strength and I am glad to have to the opportunity to be part of a great team and community.

BAMRR

we need YOU

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.

FURTHER MRI COURSE

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

LONDON SPRING 2014

at the

Royal Bournemouth Hospital

for Radiographers with some MRI experience

watch

www.bamrr.org

for more information

NEW!!!! BAMRR is now on Facebook & Twitter

On Facebook, search for **"BAMRR"** - be our fan and 'like' us and we will keep you update.

twitter For tweeting visit **twitter.com/#!/BAMRR**

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◆ **Celia O'Meara**

Following qualification from University of Wales, Bangor I started my career at University College London Hospitals. After 18 months in post, I left to join the Royal Marsden Hospital where I gained mammography and cross-sectional imaging experience. I completed both a certificate of mammography competency and a PgCert in MRI during my time at RMH.

My next post was at Guy's and St Thomas' Hospitals, where I worked as a MRI radiographer. This post provided me with experience in imaging many different patient groups, and also provided me with cardiac MR training. I was also lucky enough to be an Olympic Gamesmaker, working in the medical centre.

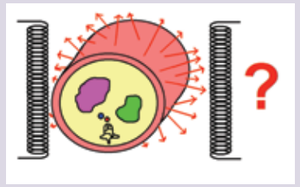
Since March 2012, I have been superintendent radiographer within the UK's first PETMR scanner. This has been an interesting and challenging post as I provide both clinical and research services. The PETMR scanner is hybrid system which allows for the simultaneous acquisition of both PET and MR data.

I joined the BAMRR policy board in June, as I was keen to create links with other MR radiographers, especially those involved in research. In addition, the PETMR scanner is located within the Nuclear Medicine department, and I feel part of my role as superintendent is to help create knowledge and understanding amongst the MR community about its functions and capabilities. At the latest policy board meeting, I became BAMRR secretary, and lead tweeter! Please do follow us @BAMRR

Spatial Encoding
Part 3 – Frequency Encoding

Matthew Benbow *Superintendent Radiographer Royal Bournemouth Hospital*

Introduction



Spatial Encoding describes a series of processes employed by an MRI scanner to establish exactly where signals within the patient have originated, in order that meaningful images can be produced. The x, y and z gradients all need to be utilised to make this process possible.

In the previous two editions of BAMRR News we have looked at the steps of Slice Selection and Phase Encoding. However for standard 2D imaging this is still not enough. One more spatial dimension remains to be encoded in order to finally resolve each point within the patient. This is the process of Frequency Encoding.

With Slice Selection, we established that we are able to excite, and therefore only receive signals from, one slice at a time. Then after Phase Encoding, we could establish from where along either the x or y axis (depending on the directions we choose to perform phase and frequency encoding – we can swap these) the signal originated, i.e. we can establish from which column or from which row. Now we will use Frequency Encoding to finally encode the signal to a single point in space.

We will continue describing the process of acquiring axial slices, but remember, merely by changing the use of the x, y and z gradients, the scanner is able to produce slices in any plane we choose.

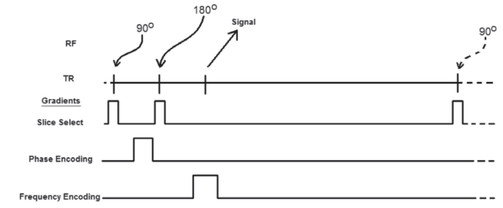
◆ **Image 2**

Image 2 shows the phase position of the protons as described in the previous article, immediately following left to right phase encoding. The RF aligned protons were either accelerated or decelerated by use of the x gradient, such that it resulted in each column of protons being slightly out of phase with its neighbours by a predictable amount.

The scanner software is therefore now able to establish from which column each signal originates, but as yet, not which row. To establish this, we perform Frequency Encoding. This time, the y gradient is switched on at the same time the signal is being sampled in the receiving coil. This forces the precessing protons to spin at different angular velocities, with a velocity that is dependant on their position along the y axis. Where the gradient strength is reduced, the spins will slow, where it is stronger, the spins will speed up. The net result is that by considering the angular velocity of any signal during read-out, the scanner can establish where along the y axis, i.e. which row, it has originated. Adding this new information to the previous, it can finally resolve each signal to a point in space, and therefore generate an accurate image.

Frequency Encoding and Scan Time

Unlike phase encoding. there is no time penalty for increasing the image resolution in the frequency direction. This is because frequency encoding is performed during each of the already existing TR time periods, whereas for every line of phase resolution chosen, an additional TR needs to be performed. So whilst an increase in either phase or frequency resolution will reduce the signal to noise ratio due to voxels becoming smaller, only phase encoding affects overall scan time.



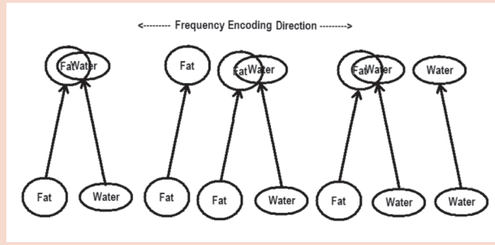
◆ **Image 3**

Image 3 shows the use of the x, y and z gradient to show how each is switched on and off so that spatial encoding is achieved. It shows a single TR period, which would fill one line of k space. This needs to repeated with a different strength of phase encoding gradient for each line of k space to be filled, which in turn depends on the phase resolution chosen.

Sampling Time and Bandwidth

The length of time the frequency encoding gradient is switched on for is called the sampling time. Whilst the gradient is on, protons will be forced to precess at different frequencies across the gradient. This range of frequencies is known as the receive bandwidth. The higher the chosen image resolution in the frequency direction, the more samples are needed and therefore either the bandwidth will need to be increased, or alternatively, the bandwidth can be kept the same if more time is allowed to collect the samples, i.e. the sampling time is increased. If the sampling time is increased too much, this will affect the minimum TE available as it will encroach on the rephasing pulse. Generally scanner operators have no control over sampling time, however the receive bandwidth is available to adjust. This may be useful in certain circumstances, e.g. increasing it to reduce distortion artefacts from metallic prostheses. It should be remembered that increasing bandwidth (just as increasing resolution) has an adverse effect on signal to noise ratio.

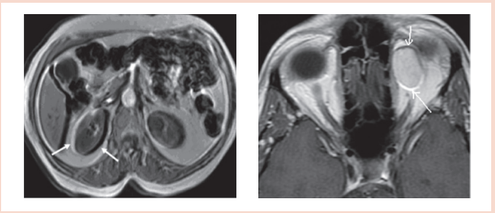
Some scanner manufacturers measure bandwidth in Hz (or kHz) whilst others use Hz/pixel, so a small calculation may be needed to compare protocols between vendors.



◆ **Image 4**

Chemical Shift Artefact

The Larmor equation tells us that in a fixed magnetic field, hydrogen precesses at a predictable and fixed frequency. In reality minor changes in this frequency occur in vivo as hydrogen is bonded to form part of different molecules. The obvious examples are hydrogen in fat and hydrogen in water, where in a 1.5T scanner, fat precesses 224Hz slower than water. This is not a great deal, but remember that the frequency sampled during frequency encoding governs where the signal is placed in the image. The result is that the hydrogen producing signal in fat can be mapped to a slightly shifted position in the frequency encoding direction, to that of fat.



◆ **Image 5**

To help reduce chemical shift artefact the bandwidth can be increased so that the physical difference of the two shifts is smaller. This is a bit like the fact that missing an archery target by 20 cms is better than missing by 20 inches.

Frequency Wrap

So based on the frequency of a spin, we have learned that it is mapped into its correct position in the frequency direction of the final image. It is therefore of course important that the frequency sampled and measured is correct. If not, it could be mismapped into a false position and possibly even wrap. Consider this analogy. If you were floating in space and saw planet earth in the distance you may realise that it is spinning and be curious how fast.

If you took a photo every 30 hours and then reviewed them after a week, would this be enough? The answer is no, because it would lead you to believe that it was turning just 90° between each picture and therefore had a day length of 120 hours. The problem is that you are not taking a sample picture often enough. What about a photo every 15 hours, is that enough? The first picture would correctly suggest just over ½ a turn, the next would suggest (correctly also) a turn and a quarter. By photo 9 the earth will be in the same position as it was for photo 1, and will have appeared to have spun 5 times, i.e. 5 times in 120 hours, suggesting a day length of 24 hours. So what changed? Why was a sampling rate of 15 hours enough to get the correct result, but 30 hours was not? This is explained by a principal called the Nyquist-Shannon Theorem (or Sampling Theorem) which states that each signal must be sampled a minimum of twice per cycle in order to correctly measure it. It is therefore built in to all modern MRI scanners for this to happen so that samples are correctly measured, and frequency wrap does not occur.

So by the use of Slice Selection, Phase Encoding and finally Frequency Encoding MRI signals can be spatially resolved in all 3 dimensions such that diagnostic images can be accurately created.

ULTRASMALL SUPERPARAMAGNETIC IRON OXIDE

An Application to Lymph Node Staging Within MR Cancer Imaging

By Rochelle Gardiner Bachelor of Applied Science (Medical Imaging)

For decades significant research has taken place amongst Magnetic Resonance Imaging fields into the development of superparamagnetic nanoparticles, particularly Ultrasmall Superparamagnetic Iron Oxide (USPIO) nanoparticles, and their application to lymph node staging and related metastases in various cancers. These USPIO nanoparticles 'are taken up by macrophages within lymph nodes and reduce their signal intensity caused by T2 shortening and susceptibility effects of the iron oxide'. (Gharehaghaji *et al*, 2009) By explaining the chemical composition of USPIOs, discussing the magnetic properties of iron oxide, and applying these properties to MR imaging, it is hoped their ability and potential can be recognised in metastatic lymph node MR imaging.

USPIO Chemical Composition

Ultrasmall Superparamagnetic Iron Oxide (USPIO) nanoparticles are a T2 Contrast Agent within MRI scanning departments. Its chemical composition is very complex as particles must be appropriately small to be internalised *in vivo*. The coating material must assist in stabilising insoluble iron oxide particles within solution whilst moreover, acting as a surface functionalisation for these particles to target specific *in vivo* structures.

Maghemite Fe2O3 and Magnetite Fe3O4 are both iron oxide cores that are predominately used as USPIO nanoparticles. Both metal ions occupy ferrite crystal structures that allow net spontaneous magnetisation of the iron nanoparticle. A polymeric coating of Dextran is used as the coating material in USPIOs. Dextran is a carbohydrate and is composed of a branched polysaccharide consisting of multiple glucose units joined through glycosidic linkages which bind to the iron oxide core by means of hydroxyl interactions. This chemical bond allows for stabilisation against aggregation. The coating thickness determines the difference in physiological nanoparticle retention post injection. A half-life of greater than 24 hours is necessary for MR Imaging requirements prior to nanoparticle breakdown and excretion through physiological iron consumption of the liver. Including the coating USPIOs entire nanoparticle size is never greater than 10nm.

Magnetic Susceptibility

Magnetic susceptibility is the degree of magnetisation a material responds to a magnetic field. There are three types of substances – each with different magnetic susceptibility:

Diamagnetic Paramagnetic Ferromagnetic

'Paramagnetic substances contain unpaired electrons, have a small positive charge and are weakly attracted to the external magnetic field.' (Hashemi, Bradley and Lisanti, 2010) Gadolinium, a rare earth element is a strong paramagnetic substance due to its seven unpaired electrons. Haemoglobin, the breakdown of blood products from haemorrhage, is paramagnetic. For example, deoxyhaeoglobin has four unpaired electrons whilst methemoglobin has five unpaired electrons. It is within paramagnetic substances that superparamagnetic substances arise with magnetic susceptibilities 100 to 1000 times stronger than paramagnetic substances.

Iron oxide is a superparamagnetic substance.

Ultrasmall Superparamagnetic Iron Oxide (USPIO) superparamagnetism occurs when the structure size is smaller than the ferromagnetic domain and the structure contains no net magnetisation remnants upon removal of an external magnetic field. Within MRI, USPIOs most important property is their ability to significantly shorten T1 and T2 relaxation times.

Relaxivity of Superparamagnetic Materials

$$R_2 = \frac{1}{T_2} = \frac{1}{T_{2a}} + \chi C$$

Where...
R_2 is the T2 proton relaxation rate / rate T2 agents attenuate the MR signal
T_{2a} is defined as the observed relaxation time
T_2 is the T2 in the absence of contrast agents
C is the contrast agent concentration
χ is the relativity of the material - (measure of how much the proton relaxation rate is increased per unit of concentration of contrast medium)

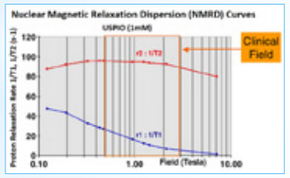
To generalise this concept to incorporate both T1 and T2 proton relaxation rates:

$$R_{1,2} = R'_{1,2} + \chi C$$

Where...
$R_{1,2}$ (unit s^{-1}) is the respective T1 or T2 proton relaxation rate in the presence of the contrast agent
$R'_{1,2}$ are the relaxation rates in the absence of the contrast agent

Figure 1: ← Complex equations detailing the relaxivity of superparamagnetic materials. (Carot *et al.*, 2006, p. 1478 and De *et al.*, 2011, p. 1284)

Figure 2: ↓ A visual representation of the relaxivity of USPIO within a Nuclear Magnetic Relaxation Dispersion Curve. (Carot *et al.*, 2006, p. 1479)



Through application of the equations in Figure 1 and reflection upon the USPIO NMRD curve from Figure 2, it may be concluded that USPIO's generates negative contrast by creating a large magnetic field gradient. 'Unlike T1 agents, which retard longitudinal proton relaxation, T2 agents expedite transverse relaxation through the loss of coherence. In T2 weighted images, T2 contrast agents attenuate signal intensity, and therefore appear dark.' (De *et al.*, 2011)

Combined USPIO Chemical Composition and

$$R_2 = \frac{1}{T_2} = (\mu_{sp} N_g)^2 \left[\frac{64\pi}{135}\right]\left[\frac{\mu_0 \gamma L(x)}{4\pi}\right]^2 \left[\frac{N_A C_a}{R_a D}\right]$$

Where...
μ_{sp} is the magnetic moment of one nanoparticle
N_g is the number of nanoparticles per agglomerated structure
μ_0 is the permittivity of free space
γ is the protons gyromagnetic ratio
N_A is Avagadro's number
C_a is the agglomerated concentration
R_a is the agglomerated radius
D the diffusivity of water
$L(X)$ the Langevin function with respect to $X = \mu_{sp} N_g B_0/(kT)$

Figure 3: ← Combined chemistry and physics from previous Magnetic Susceptibility and USPIOs Chemical Composition, resulting in an equation that details the relaxivity of T2 Contrast Agent: USPIO. (De *et al.*, 2011, p. 1284)

From this, the important aspect concerning T2 Contrast Agents relaxation processes and susceptibility induced artefact in subsequent MR imaging is that:

'The R_2 is proportional to the to the square of the individual magnetic moments μ_{sp} and the number of the particles in each aggregate N_g.' (De *et al*, 2011)

MRI Sequences:

The single most important imaging parameter causing attenuated signal intensity of USPIOs due to magnetic susceptibility is the amount of phase dispersion caused by a combination of pulse sequence parameters and the USPIO. To explain this further:

Figure 4: → Equations used to determine the Phase Spread within a voxel and the difference in the local magnetic susceptibilities between contrast agents compartment and the surrounding tissue. (Graves, 2007)

$\Delta\phi$ = Phase Spread within a single voxel given by the equation:

$$\Delta\phi \propto \Delta\chi \, \Delta r \, TE$$

where...
γ = gyromagnetic ratio
Δr = voxel size
TE = echo time
$\Delta\chi$ = difference in the local magnetic susceptibilities between agent compartment and the surrounding tissue

$$\Delta\chi \propto 4\pi\chi_m C$$

where...
χ_m = the agents molar susceptibility
C = the agents concentration

Within MRI, from Figure 4, it can be seen that pixel size and TE are directly proportional to Phase Spread. Although, MRI being filled with trade-offs and compensation, encouraging susceptibility by increasing Phase Spread is done by increasing the pixel size with direct undesirable consequence to spatial resolution. Furthermore, encouraging phase spread by increasing the pulse sequence TE is a detriment to image Signal-to-Noise Ratio (SNR).

'Gradient Echo sequences are most sensitive to susceptibility artefacts than Spin Echo because of the lack of refocusing pulses in GRE sequences. This 180^0 refocusing pulse in Spin Echo simply acts to refocus residual magnetisations.' (Oghabian *et al.*, 2010) Tracking labelled cells on sequences that delineate susceptibility artefacts well, particularly T2 Gradient Echo sequences should increase the accuracy and specificity of detection of the labelled cells.

Physiological Pathway *In Vivo*

The Dextran coating allows USPIOs to be internalised by macrophages or other phagocytic cells of the Reticuloendothelial System (RES) following intravenous administration. This combined with a long half-life allows USPIOs time to Infiltrate macrophages located deep within pathological tissues. An important trait of metastatic tumours is their deficiency in macrophages. Utilising USPIO to its best capacity involves an MR examination pre contrast, administration of USPIO to the patient intravenously and imposing a lengthy delay of approximately 24 hours post administration prior to repeat MR Imaging. Lymph nodes displaying a healthy dispersion of macrophages will present as negative contrast on T2 Gradient Echo sequence whereas, tumour infiltrated portions of lymph nodes will display no susceptibility induced negative contrast.

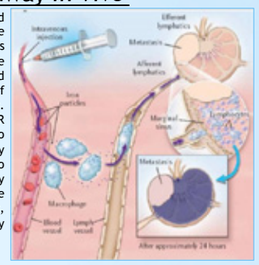


Figure 5: → Schematic pathway of USPIO uptake in lymph nodes. (Pultrum *et al.*, 2009)

Application to Cancer Imaging

Metastatic invasion of regional lymph nodes is an adverse pathological progression within malignant cancers that requires an accurate diagnosis because it permits adequate staging and separates those patients who may benefit from cancer/node resection surgery. 'Current morphologic assessment of lymph nodes based on size and shape as determined by CT or MRI is unable to detect smaller metastases in normal-sized nodes.' (Thoeny *et al.*, 2009) This unfortunately limited lymph node assessment necessitates a need for improved detection sensitivity and specificity and USPIO-Enhanced MRI is one of the most promising modalities for the evaluation of the lymph-node metastases in patients with cancer.

Post USPIO injection, normal lymph nodes exhibit a reduction in their signal intensity caused by T2 shortening and susceptibility effects of the iron oxide. 'Metastatic lymph nodes, in which macrophages are replaced by tumour cells do not exhibit USPIO uptake and their signal intensity remains unchanged on post contrast images.' (Gharehaghaji *et al.*, 2009) By referring to Figure 6 to assist in image interpretation, it can be seen that USPIO nanoparticles demonstrate negative enhancement of non-tumour filled lymph nodes 24 hours after intravenous injection. This allows visualisation and differentiation between healthy lymph nodes and metastatic infiltrated nodes.

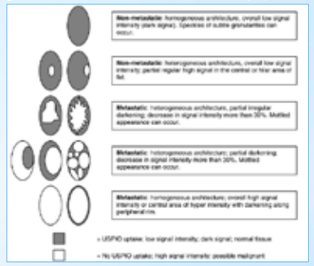


Figure 6: → Schematic diagnostic guidelines for USPIO-Enhanced MR Imaging. Nodes are considered malignant when one of the following criteria are present: a decrease in signal intensity of less than 30% on T2 Weighted Gradient Echo sequences after administration of USPIO; a heterogeneous signal (giving the entire node a mottled appearance), discrete focal defects (isolated islands of high signal intensity), or both; and nodes with a central area of hyperintensity (excluding fatty hilum) but a peripheral decrease in signal intensity. (Pultrum *et al.*, 2009)

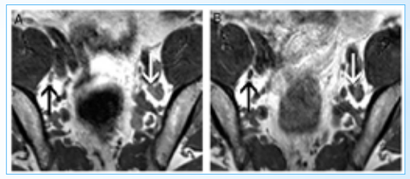


Figure 7: ← An example of USPIO uptake in positive and negative lymph nodes. These images from the same anatomical location are Axial T2 Weighted Gradient Echo images before (A) and after (B) the administration of USPIO in a 67-year-old prostate cancer patient. The benign lymph node (black arrow) shows a decrease in signal intensity after the uptake of USPIO; the malignant lymph node (white arrow) shows only partial posterior and medial signal decrease after the administration of USPIO. (Triantafyllou *et al.*, 2013)

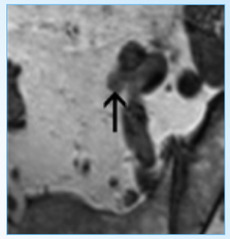


Figure 8: → An example of a lymph node metastasis (black arrow) localised between the left proximal internal and external iliac artery shown in an Axial Reconstructed T2 Gradient Echo image, 24 hours after USPIO administration. This patient, a 60-year-old gentleman with bladder and prostate cancer, has demonstrated no USPIO uptake within this lymph node which is indicative of a nodal metastasis. Such a metastasis may have easily been missed using conventional MRI Scanning, resulting in incorrect staging. (Triantafyllou *et al.*, 2013)

Results from research conducted by Triantafyllou *et al.*, (2013) indicates that 'USPIO-enhanced MRI enables detection of lymph node metastases in normal sized lymph nodes in cancer patients staged as metastasis free (N0) when compared directly to conventional cross sectional imaging methods.' Additionally, 'high sensitivities ranging from 81 to 100%, specificities ranging from 77 to 98% and accuracies ranging from 86 to 95% have been reported for MR combined USPIO lymph node staging for different types of tumours.' (Pultrum *et al.*, 2009)

Conclusion

USPIOs role within MR Imaging departments is as a T2 Contrast Agent. It offers an exciting avenue to assist in the accurate diagnosis of lymph node metastases, an adverse pathological progression of cancer. In recent years USPIO T2 Contrast has been disapproved by health authorities, however, it is hoped that with rigorous trialling and testing on developed derivatives of USPIOs that an accepted product will be available soon. By understanding the chemical properties necessary of these nanoparticles, recognising the physical purpose of susceptibility induced artefacts to encourage this phenomenon, and appreciation of the physiological pathway necessary to image lymph nodes, USPIOs can be understood and their role asserted on malignant lymph node/cancer staging. An accurate diagnosis that includes precise assessment of lymph nodes will improve cancer patients' prognosis through resection of affected nodes.

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EU PAD UPDATE

BACKGROUND

The European Union Physical Agents Directive1 (EUPAD) concerning Electro-Magnetic Fields was finally formally adopted in June 2013 bringing to a conclusion one of the most complicated and exceptionally delayed directives, and ultimately bringing a degree of certainty to the continued use and development of MRI within the healthcare sector.

This Directive repeals the originally adopted Directive of 2004 which inadvertently resulted in many activities within MRI being severely restricted due to worker exposures above the theoretically set exposure limit values (ELV's) to the extent that everyday activities such as leaning into the bore of a magnet to check the patient, interventional procedures, and cleaning and servicing of the scanners would be prohibited.

The MR community in the UK along with the Alliance for MRI , a lobbying group of European MR Stakeholders formed in response to the 2004 directive worked together to influence the European Commission (EC) resulting in an amending directive being adopted in 2008 ,delaying implementation of the original directive until 2012. This delay was granted to allow the EC to consult stakeholders from across Europe on the future of the directive and allow time for scientific studies to analyse the impact of the directive on the use of MRI. The study ordered by the commission demonstrated that compulsory compliance with the ELV's in the original version would indeed significantly curtail the use and development of MRI. A new draft directive was produced allowing for a conditional derogation for MRI from the ELV's and a revision of the limits.

Further delays then occurred, as this directive affects many sectors such as the automotive, energy, telecommunications amongst others, who generally along with their Trade Unions initially were resistant to derogation for MRI. An unprecedented additional delay was granted following the rejection of an impact assessment in 2011. The draft underwent many revisions until all member states were happy to reach agreement.

THE ADOPTED DIRECTIVE NEXT STEPS

The Directive which was agreed and adopted in 2013 has conditionally retained the derogation for MRI from the ELV's. A copy of the published version can be viewed online:

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:179:0001:0021:EN:PDF

The transposition date is 1st July 2016 and the Health and Safety Executive (HSE) will be publishing UK guidance to support implementation of this directive. HSE will work closely with all stakeholders involved in developing this practical guidance. BAMMR and the Society and College of Radiographers will work with the HSE as members of an MR sub group during development of this guidance.

1. Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC
2. Directive 2004/40/EC of the European Parliament and of the Council of 29th April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

Importance of Magnetic Resonance Imaging in the assessment of spinal emergencies in companion animals

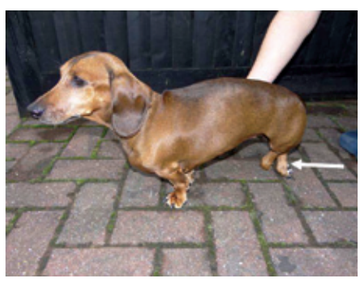
J Jovanovik, C Zindl, N Fitzpatrick, M Farrel

"The greatness of a nation and its moral progress can be judged by the way its animals are treated"
Mohandas Gandhi

Introduction

The importance of animals in everyday life is progressively increasing, not only as family pets but also as working and performance animals. In veterinary medicine spinal pathology is the most prevalent emergency pathology in small animal practices. That requires prompt and accurate diagnosis, allowing appropriate treatment for the animal. Limitation of the availability of advanced diagnostic imaging, particularly high field Magnetic Resonance Imaging (MRI) systems in general veterinary practices, can delay diagnosis. This can have a deleterious impact on case management for affected animals. We have assessed the current published literature concerning the diagnosis of spinal pathology in companion animals using MRI in order to establish whether emergency MRI is justifiable in these patients.

Spinal emergency at 7pm!?

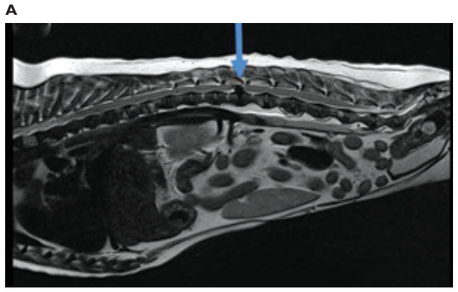


◆ **Figure 1: The white arrow is pointing to the hind leg of a Dachshund affected by acute onset of paraplegia. Knuckling of the paw indicates that a spinal cord injury is present.**

Spinal cord injuries in companion animals often have similar causes to equivalent injuries in humans. In addition to traumatic injuries from falls, kicks or motor vehicle trauma other causes include congenital or developmental vertebral malformation and neoplasia. Above all of these causes in terms of prevalence, is acute spinal cord compression caused by degenerative intervertebral disc disease (IVDD). This high prevalence in dogs is a consequence of the chondrodystrophic trait common to "dwarf" dogs including the Dachshund and spaniel breeds. Parent (2010), has discussed that even after detailed clinical neurological examination, the list of differential diagnoses for spinal pathology is long. Thus, neuro-imaging is needed to establish a definitive diagnosis as part of the routine investigation of the emergency spinal case. In human medicine, spinal cord compression is most commonly investigated with MRI as the diagnostic modality of choice due to its ability to acquire high quality images of spinal cord and nerve root pathology as well as the important surrounding anatomy including ligaments, blood vessels and intervertebral discs (da Costa et al, 2010).

Gallach et al (2011) have reported specificity and sensitivity of T2W sequence of 91.5% and 95.8% respectively for intramedullary spinal cord pathology. They justified MRI as the modality of choice for veterinary spinal disorders because of the rapid acquisition of accurate images. In addition, Levine et al (2009) retrospectively reviewed data from multiple institutions and compared the imaging and clinical findings with patient outcome with the aim of determining the value of the MRI scan. It was concluded that high field MRI systems provided greater image quality and that the degree of hyperintensity within the spinal cord parenchyma was valuable in predicting patient outcome. Furthermore, it was reported that dogs diagnosed with spinal cord compression due to disc extrusion (figure 2) that underwent decompressive surgery immediately after the MRI scan had rapid recoveries and improved functionality in the long term.

A



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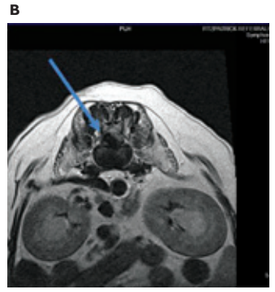


◆ **Figure 2: MRI of the thoracolumabar spine in a Dachshund with intervertebral disc extrusion in (A) Sagittal plane and (B) Transverse. The blue arrow is pointing at the disc extrusion**

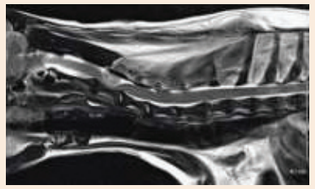
In a study reported by De Rosio et al (2009), MRI images performed in sagittal and transverse planes in T2 weighted contrast sequences provided an accurate antemortem diagnosis in acute paraparesis caused by non-compressive nucleus pulposus extrusion. The authors concluded that this data could be crucial in guiding the decision-making process for ongoing clinical treatment of affected animals.

In some dog breeds, congenital or developmental spinal disorders predispose to myelopathy later in life. For example, cervical vertebral anomalies in the Doberman Pinscher have been investigated by De Costa et al (2005). Morphologic and morphometric analyses of the cervical vertebrae in normal Dobermans and Dobermans with clinical signs of cervical myelopathy were evaluated and compared. For these evaluations, MRI was deemed superior to myelography or CT for the concurrent assessment of osseous abnormalities and intervertebral disc pathology, using T2 GRE sequences in addition to standard T2 weighted sequences. MRI has also proven of great value in the investigation of spinal cord pathology in cats with various neurological signs.

In addition to dogs, MRI has been proven of great value as an additional modality in the investigation of spinal cord pathology in cats with different neurological signs. In the study of R. Gonçalves et al (2008) it was presented that the cats with significant clinical signs and unexplained pain are indicative of significant pathology presented on MRI scans.

Traditionally, image interpretation in veterinary radiology parallels the investigation methods used in human medicine because tissue contrast on MRI images is comparable (Bergknut et al, 2011). Nevertheless, some of the design features of high field MRI systems are not particularly animal friendly. This can pose significant challenges for the radiographer who is frequently obliged to improvise animal positioning and scanning techniques in order to obtain high quality diagnostic images. One of the most important requirements in veterinary MRI is general anaesthesia. Above all, this requires close team work between veterinary clinicians, nurses and radiographers with the aim to safely achieve a fast and accurate diagnosis. Furthermore, wide adjustments in the MRI parameters are often necessary to obtain high quality images because animal size varies dramatically, for example, between Dachshunds and Great Danes. This size variation will significantly influence SNR, FOV and scan time, which collectively constitute the main factors determining image quality. Moreover, the slice thickness, matrix and rest of other image factors will also vary, adding to the complexity in achieving diagnostic images within a reasonable scanning time. Enthusiastic veterinary surgeons and radiographers are responding on those challenges with great dedication to transform the latest research achievements into part of the routine care of animals as well as humans. A study by Pease and Miller, (2011) confirmed that the Diffusion Tensor Imaging (DTI) of the spinal cord in dogs can produce useful data in the evaluation of the severity of the spinal cord disease. This novel technique of imaging axonal bundles of the spinal cord can be of great value to the clinician in establishing an accurate, because the evaluation of the nerve root damage in cases of spinal cord myelomalacia was more easily detected in comparison to the mild hyperintense signal on standard T2 weighted images. In addition, this technique proved helpful to the neurosurgeons in planning resection of a extradural tumour removal (figure 3).

A



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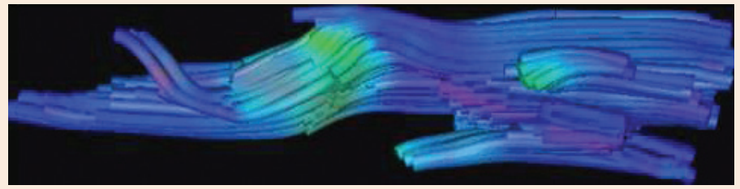

◆ **Figure 3: Sagittal T2-weighted image (A) and tractography (B) of the cervical region (image courtesy of A Pearse and R Miller)**

Conclusion

Even though routine radiographs and myelography are available to most primary care practices, these techniques offer suboptimal sensitivity to aid the clinician in determining the severity of the level of spinal cord injury and hence the prognosis. This fact was concluded in the study of Parry et al (2010), who demonstrated a clear effect of MRI on the decision-making process for optimal patient care because the MRI images provided significantly clearer information in comparison to myelography. The lack of widespread availability of high field MRI scanners as well as the need for extensive training in the MRI scanning and image interpretation of companion animals is a current challenge in veterinary medicine. Nevertheless, rapid technological development of the MRI scanner hardware and development of faster sequence acquisitions promotes the potential for MRI as the future standard of care in companion animal medicine.

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Critical Evaluation of experience and attitudes of MRI Radiographers in an independent healthcare provider to Continuous Professional Development

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Introduction

The HPC (2010) defines CPD as

"A process of lifelong learning for all individual and teams through which Healthcare Professionals maintain and develop throughout their career to ensure that they retain their capacity to practise safely, effectively and legally with their evolving scope of practice and which enables the professionals to expand and fulfil their potential"

CPD

Figure 1 CPD Model: Courtesy of CIPD 2010

The cyclic nature of CPD is shown in Figure 1, for reflection, review and advancement for Chartered Institute of Professional Development (2010).

Investigation

The research is to investigate the MRI radiographers in an independent healthcare provider and examine their experiences and attitudes to CPD.

The group's activity, perceptions, awareness, engagements and provisions for CPD and any barriers or challenges faced.

The HPC has linking registration with CPD and undertakes a two yearly national audit of CPD profiles and evidence

Has audit been a important instrument to ensure engagements or does the motivation and awareness come from the profession developing?.

Also are there systematic barriers that are faced to reflective practice and embracing evidence based practices in the workplace?

Methods

The researcher investigated a sample of 135 imaging radiographers and their motivation and attitudes to CPD using an Lime Survey, an online questionnaire. Data was gathered with regards to motivation, awareness and well as barriers and challenges. The responses rate was 40% (n=53)

The online questionnaire would allow remote access, as a large number of participants at are geographically scattered over the UK. It is user friendly as a familiar format to group, and gives the participant anonymity.

Qualitative methods involving closed, semi-structure scaled questions were used as well as quantitative data from open ended questions that were themed.

Questions asked covered the following areas;

•Awareness and attitudes to CPD post national audit

•Awareness of CPD Profile needed to fulfil HPC criteria

•Explore CPD activities in terms of beneficial to personal, team or organisation development.

•Consider themes to challenges and barriers to CPD engagement

•Attitudes to lifelong learning and evidence based practice.

•Examine participation in present and future research projects.

Results

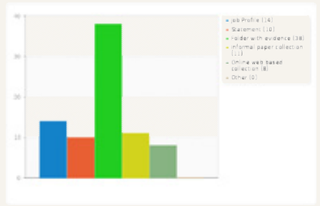

Figure 2 HPC Profile Awareness

The requirements were a job profile covering practice history, a personal statement on how the standards have been met and supporting evidence for the last 2 years.

The responds showed that 51% were unaware of the specific design and 49% were aware of the format, This is supported by the feedback from the profile data that only 29% had a job profile and 21% had a statement in place, two essential elements to the HPC CPD profile. Figure 2 .

Other data extracted showed that the group had good understanding of CPD activities (61%), time frame (63 %) and evidence (57%) needed for HPC Profile.

Figure 3 Appraisal sharing

The responses was strongly for, with 79% stating that they did not have a problem or issue with linking CPD and performance management. However 21% had negative view and were unhappy to share their CPD with their employer.

The appraisal system is a complex progress and involves assessment, objective-setting and formal feedback. A number of staff can find these processes difficult, as weakness are evaluated and it requires an amount of self-investigation (Armstrong 1998)

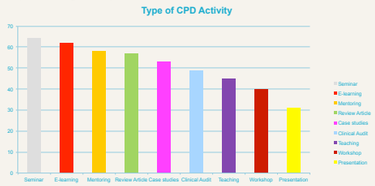

Figure 4 CPD Activities

The activity most favoured by the group (64%) was the seminar or conference. These results are in keeping with conclusions drawn by Henwood (2012), who also noted a clear preference to attending forums or symposiums.

E-learning was the next highest ranked activity and this may be contributed to better computer and internet access in recent years.

With healthcare professionals being located over a large geographical area, access to the group can be service by e-learning at a low cost and high population reach (Gibbs 2011) .

Comments

Direct comments from the individuals

Positive

"It gives me the ability to understand evidence based practice"

"I feel it gives me confidence in my work and enables me to understand the reasons behind what I do and why i.e. Evidence based practice. I know I can be proud that I move with the times to provide the best service I can."

"The area I work in is constantly changing, CPD keeps me up to date"

"I can put into practice knowledge from CPD, ie case studies and conference presentations."

Negative

"Time and commitment to do this work is my main problem- in a role where I already feel I am over stretched".

Conclusions

Awareness

There is clearly a difference between these findings and Henwood (2004), where that research showed poor awareness of breath and scope of activities which constitute CPD. With the link to registration and audit, the group have shown that they embrace CPD and activities are varied.

Understanding

The results here show a marked transform in the CPD understanding from Palarm (2001) and a much wider knowledge of variety and spread that the individual can draw on to engage in CPD. In almost 12 years the awareness has improved dramatically

Appraisal

It should be seen as a two way process which the manager learns more about their teams, problems, needs, skills and aspirations in careers terms. Thus aided the organisations to build on the teams skills and facilitate individual, team and organisational development., thus CPD links with performance management.

Recommendations

•CPD Activities should be specific to the group i.e. e -learning and workshops
•CPD Profile awareness means to be raised within the group
•Run workshops on CPD profiles
•Link CPD to appraisal and performance management
•CPD coordinator to aid links between management and staff

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