highly specialised services in England and provides care for approximately 100 of these children. The Trust provides a multidisciplinary care model, including highly specialised input from pharmacology, physiotherapy and imaging. This comprises of a weekly multidisciplinary clinic, an outreach service and an inpatient service for drug treatment and therapy interventions. This poster aims to showcase the radiographic techniques used at GOSH to monitor children with OI. It will outline imaging techniques used, the rationale behind them and how this method harnesses the clinical expertise of the Radiology team to provide an evidence-based, high-quality imaging service for children with OI. Learning outcomes include, how to safely image children with "brittle bones" and the importance of a multi- imaging modality approach. Most importantly, we aim to highlight that this multidisciplinary approach is essential for successful diagnosis and management of the condition.

E5.5 Referred otalgia - pearls and pitfalls for the general radiologist

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Background: Pain referred to the ear, known as referred (or secondary) otalgia, is a common presentation to the ENT surgeon. Its mechanism is complex, due to the confluence of multiple sensory pathways that include the cranial nerves V, VII, IX, X and cervical nerves C2 and C3, resulting in uncertainty of the central nervous system to pinpoint the exact location of the abnormality.

Referred otalgia is a 'reg flag' symptom for ENT surgeons, necessitating a thorough clinical history and examination, which includes review of the ear, oral cavity, teeth, temporomandibular joint, neck/cervical spine and fibreoptic nasendoscopy of the upper aerodigestive tract. It is common for the site of pathology to be clinically occult, especially if pathology lies at the skull base, postcricoid, submucosal or parapharyngeal spaces for example. Therefore, imaging plays a vital role in the diagnostic workup of referred otalgia.

It should be noted that the diagnostic yield of referred otalgia imaging for significant pathology is low (except in patients with past history of head and neck cancer). [1]Nevertheless imaging remains central to the referred otalgia diagnostic pathway to minimise risk of missing head and neck malignancy.

Purpose: To review the sensory pathways that supply the ear, to explore the regions of the head and neck that also share sensory innervation, and to demonstrate the important pathologies causing referred otalgia.

Summary: The poster will present a pictorial review of the relevant anatomy and important pathologies relevant to referred otalgia imaging, aimed at both general and head & neck radiologists.

1. Ainsworth, E., Pai, I., Kathirgamanathan, M. and Connor, S.E.J. (2020) Diagnostic Yield and Therapeutic Impact of Face and Neck Imaging in Patients Referred with Otalgia without Clinically Overt Disease. *American Journal of Neuroradiology*, 41(11), 2126-2131.

Proffered papers: Imaging technology

F6.1 Cardiac sorting in routine 4DCT data

Mark Wrobel[1]; Lauren Pearson[1]; Alan McWilliam[1]; Mark Gooding[2]; Corinne Faivre-Finn[3]; Marcel van Herk[1]

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Background: 4DCT scans of lung cancer patients are used for radiotherapy planning. Respiratory motion is currently well defined. However, the heart is blurred due to cardiac motion leading to poor definition of substructures to be spared in the future. This leads to potential excess damage of such structures during radiotherapy. This project aims to correct standard 4DCT for cardiac motion and improve image quality.

Method: DICOM data from ten radiotherapy 4DCT scans (Phillips Brilliance Big Bore) was registered on the heart to compensate respiratory motion. Next, we find and merge slices acquired in different cardiac phases. The mean area of all slices as function of time shows pulsation of blood vessels in the neck. Fourier transform was performed to detect the heartbeat frequency and exact frequency and phase found by fitting a trial function to the data. Finally, the 4DCT scans slices were sorted based on the parameters and merged to obtain cardiac sorted scans.

Results: The heart can be seen at different points in the cardiac cycle in Fig.1. The beating heart outside diastole is shown in the left image causing blurriness and doubling of calcifications. Conversely, the right image shows the same slice location in diastole: the heart's vessels, chambers, calcifications and edge are sharp and well defined.

Conclusion: We are the first to post-process 4DCT data for radiotherapy to correct for cardiac motion. However, the method has only been tested in a limited number of patients and needs improvement for reliability.

1. Banfill, K., Giuliani, M., Aznar, M., Franks, K., McWilliam, A., Schmitt, M., Sun, F., Vozenin, M.C. and Finn, C.F., 2021. Cardiac toxicity of thoracic radiotherapy: existing evidence and future directions. Journal of Thoracic Oncology, 16(2), pp.216-227
2. McWilliam, A., Kennedy, J., Hodgson, C., Osorio, E.V., Faivre-Finn, C. and Van Herk, M., 2017. Radiation dose to heart base linked with poorer survival in lung cancer patients. European journal of cancer, 85, pp.106-113
3. McWilliam, A., Khalifa, J., Osorio, E.V., Banfill, K., Abravan, A., Faivre-Finn, C. and van Herk, M., 2020. Novel methodology to investigate the effect of radiation dose to heart substructures on overall survival. International Journal of Radiation Oncology* Biology* Physics, 108(4), pp.1073-1081
4. Van Herk, M., McWilliam, A., Banfill, K. and Faivre-Finn, C., 2020. PO-1742: Post-processing 4DCT to improve delineation of heart substructures. Radiotherapy and Oncology, 152, p.S967
5. Wolthaus, J.W.H., Sonke, J.J., Van Herk, M. and Damen, E.M.F., 2008. Reconstruction of a time-averaged midposition CT scan for radiotherapy planning of lung cancer patients using deformable registration a. Medical physics, 35(9), pp.3998-4011

F6.2 Development of 3D-printed bolus to replace wax in head and neck radiotherapy

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Radiotherapy bolus refers to tissue-equivalent material placed on the patient's surface used to alter the dose delivery to superficial areas, such as skin. Wax is a well-known bolus material but presents issues such as variations in positioning compared to the treatment plan, inconsistencies in bolus thickness and the presence of air gaps between bolus and thermoplastic shell (Fujimoto et al., 2017). We sought a more robust and accurate alternative. 3D printing courses and visits to other departments helped in researching the most suitable, cost-effective printer and material, polylactic acid (PLA), as well as establishment of a pathway from planning to printing. Commissioning testing of the material took place including comparisons to wax, such as physical checks, surface measurements, percentage depth dose (PDD) measurements and uniformity testing as well as more clinical comparisons such as gamma evaluations of a standard VMAT plan with materials moulded to an anthropomorphic phantom. A quality control procedure was also designed to check the pathway from planning to printing. Printed bolus 'fits' into place on the thermoplastic shell with evidently less air gaps compared to wax. Positioning on shell is marked for more accurate reproducibility. 100% density PLA features comparable surface dose measurements and PDD profiles to wax. Gamma analysis for PLA was also comparable, with no unusual results. Water equivalence testing also allowed us to use 9mm-thick bolus rather than 1cm, saving printing time. 3D-printed bolus has now started to be used clinically, with improved dosimetry, timesaving for staff and positive feedback from treatment radiographers.

Fujimoto, K., Shiinoki, T., Yuasa, Y., Hanazawa, H., & Shibuya, K. (2017). Efficacy of patient-specific bolus created using three-dimensional printing technique in photon radiotherapy, *Physica Medica* 38, 1–9. https://doi.org/10.1016/j.ejmp.2017.04.023

F6.3 Is Clarity ultrasound imaging an accurate method of localising the prostate compared to Cone Beam Computed Tomography (CBCT)- with fiducials?

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Background: Although fiducial marker insertion is regarded as the gold standard in terms of IGRT (1), its application must be considered carefully as the procedure can be invasive, time-consuming, and reliant on consultant expertise (2). Precision of the fiducial markers is dependent on these markers remaining in the same location and on the prostate not changing shape during treatment (3). To facilitate the acquirement non-ionising IGRT and intra-fractional prostate tracking, Clarity TPUS® (Elekta, Stockholm, Sweden) was developed (4). The main benefits of Clarity TPUS are that it is non-invasive, non-ionising and cost-effective (5). Other studies have compared fiducials to transabdominal US, which has since been proven to not be as accurate as trans-perineal, seen in this study.

Method: CBCT fiducial translations and Clarity TPUS translations for 12 prostate patients as part of the PACE-C trial were retrospectively evaluated by 3 imaging specialists.

Results:

Average shifts between 3 observers for CBCT+FM vs TPUS

	Left/right	Sup/inf	Ant/Post
Pearson r	0.821	0.916	0.849
Average diff with 95% Confidence	-0.03 ± 0.33 cm	0.12 ± 0.29 cm	-0.02 ± 0.39 cm

The intra-class correlation coefficient (ICC)

	L/R	S/I	A/P
CBCT+FM	0.97	0.99	0.99
TPUSS	0.95	0.93	0.96

Conclusion: TPUS has the benefit of no additional dose and intra-fractional monitoring, and results show a high correlation between the different modalities. Inter-observer variability is to be considered, and further research with a larger population would be of benefit.

Srinivasan, K. Mohammadi, M. and Shepherd, J. (2014) Applications of linac-mounted kilovoltage cone-beam computed tomography in modern radiation therapy: a review. Polish journal of radiology, 79, pp.181 De Los Santos, J. Popple, R. Agazaryan, N. Bayouth, J. Bissonnette, J. Bucci, M. Dieterich, S. Dong, L. Forster, K. Indelicato, D. and Langen, K. (2013) Image guided radiation therapy (IGRT) technologies for radiation therapy localization and delivery. International Journal of Radiation Oncology• Biology• Physics, 87(1), pp.33-45 Han, B., Najafi, M., Cooper, D. (2018). Evaluation of transperineal ultrasound imaging as a potential solution for target tracking during hypofractionated radiotherapy for prostate cancer. Radiat Oncol 13, 151. Lachaine, M. and Falco, T. (2013.) Intrafractional prostate motion management with the Clarity Autoscan system. Medical physics international. 1 pp. 72–80

F6.4 Muon tomography for clinical imaging: preliminary modelling-based results

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[1]KBFI, Akadeemia tee 23; [2]University of Exeter; [3]GScan OU; [4]Université catholique de Louvain; [5]Université Libanaise

Background: Development of ultra-high angular resolution tracker technology means that muons can be used for medical imaging for the first time. The purpose of this study was to provide an understanding of a cosmic-ray based tomographic system's theoretical capability of detecting osteoporosis.

Method: We built the simulation models using CERN's Geant4 software, paired with CRY (Cosmic-Ray Shower Generator), with three cases compared - healthy bone, low bone density and osteoporosis consisting of: 34% Hydroxyapatite (HA), density 1.59g/cm3; 24% HA, density 1.46g/cm3 and 14% HA, density 1.35g/cm3 respectively. We simulated the detector hardware with 12 particle-tracking layers, combined with a cosmic-ray source (CRY). Particle counts corresponded to 3 and 15 minutes exposure at sea level. Analysis was performed using machine learning methods, based on Leave One Out Cross-Validation (LOOCV).

Results: A Kolmogorov-Smirnov test yielded a peak p-value of 9.96E-24 for a comparison between a healthy bone and osteoporosis, and 4.04E-09 for a healthy bone and a low bone density case, with respective D-Values of 0.02316 and 0.01415. Kullback-Leibler Divergence was 1.000 for 3min and 0.967 for 15min acquisitions, with respective RMSE of 0.600 and 0.533.

Conclusion: The modelling indicates that it would be possible to measure different densities and compositions of bone using cosmic-ray tomography. It underpins the potential of cosmic-ray tomography as a tool for early detection of osteoporosis without involving any additional ionizing radiation.

F6.5 PACS: Direction of travel

Pauric Greenan

Greater Manchester Health and Social Care Partnership

PACS has always been in a continuous evolutionary state. 5-years is a time period that most consider a generation in PACS. Integrated Care Systems and Imaging Networks are now in charge, focusing on regional sharing and providing care as close to home as possible. Collaboration between hospitals, CDCs, and remote access comparable to in-hospital are key. The inclusion of 'other ologies' is now given and current trends are PACS-based-reporting, web, cloud, and integrated AI. Digital Pathology to set to explode and expects to slot onto PACS architecture! Fewer big players exist with two providers now having a 66% monopoly with most of the UK out to tender as part of large consortia. And with radiology arms of EPRs replacing traditional RISs, where will the cards land? There is the inherent contradiction of owning your own data yet handing it over to public cloud providers like AWS, Microsoft and Google. And with everyone moving to cloud, what happens with another WannaCry, how does your business continuity stack up? The incessant overload of AI image reading algorithms (over 70 now), when the biggest need is for AI to do its magic on workflow! Boris scanners moving waiting for a scan, to waiting for a report. And if Covid highlighted anything it was the complete inadequacy of BI in current form, absent from any live or predictive modeling. This presentation will continue the conference disruptive adoption theme by leveraging on a recent very large UK PACS procurement across Greater Manchester to discuss current trends and direction.

Proffered papers: Advanced practice & workforce development

G7.1 An evaluation of a training tool and study day in chest image interpretation

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Background: With the use of expert consensus a digital tool was developed by the research team which proved useful when teaching radiographers how to interpret chest images. The training tool included A) a search strategy training tool and B) an educational tool to communicate the search strategies using eye tracking technology. This training tool has the potential to improve interpretation skills for other healthcare professionals.

Methods: To investigate this, 31 healthcare professionals i.e. nurses and physiotherapists, were recruited and participants were randomised to receive access to the training tool (intervention group) or not to have access to the training tool (control group) for a period of 4-6 weeks. Participants were asked to interpret different sets of 20 chest images before and after the intervention period. A study day was then provided to all participants following which participants were again asked to interpret a different set of 20 chest images (n=1860). Each participant was asked to complete a questionnaire on their perceptions of the training provided.

Results: Data analysis is in progress. 50% of participants did not have experience in image interpretation prior to the study. The study day and training tool were useful in improving image interpretation skills. Participants perception of the usefulness of the tool to aid image interpretation skills varied among respondents.

Conclusion: This training tool has the potential to improve patient diagnosis and reduce healthcare costs.

1. McLaughlin, L., McConnell, J., McFadden, S., Bond, R. and Hughes, C., (2017). Methods employed for chest radiograph interpretation education for radiographers: A systematic review of the literature. Radiography, 23(4), pp.350-357. 2. McLaughlin, L., Woznitza, N., Cairns, A., McFadden, S.L., Bond, R., Hughes, C.M., Elsayed, A., Finlay, D. and McConnell, J., (2018). Digital training platform for interpreting radiographic images of the chest. Radiography, 24(2), pp.159-164. 3. McLaughlin, L., Hughes, C.M., Bond, R., McConnell, J., Cairns, A. and McFadden, S.L., (2021). The effect of a digital training tool to aid chest image interpretation: Hybridising eye tracking technology and a decision support tool. Radiography, 27(2), pp.505-511.

G7.2 Experience of a diagnostic radiographer establishing a vague symptoms cancer pathway

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[1] Macmillan Right By You; [2]Nuffield Department of Primary Care; [3]Churchill Hospital

Background: Vague symptoms pathways were developed in England by Cancer Research UK and Macmillan Cancer Support as part of the Accelerate, Coordinate and Evaluate Program. Funding was awarded to successful Hospital Trusts and Commissioners to develop their own vague symptoms pathway. The ambition of the program was to contribute to efforts to improve the numbers of early-stage cancer diagnosed and consequently improve survival. Our pathway was coordinated by the diagnostic radiology department working with primary care and general medicine within secondary care. The pathway is led by a diagnostic radiographer in a 'Navigator' role based in the diagnostic radiology department. GPs refer patients with vague symptoms potentially due to cancer but with no other 2 week wait referral symptoms. Patients have an assessment by the Navigator, a CT Chest Abdomen and Pelvis and routine screening bloods as initial investigations.

Learning outcomes:

- Rigorous referral and vetting procedures
- Creating a specific and explicit reporting proforma