

Solving Clinical Problems with Anatomical Solutions

Winter Meeting of the Anatomical Society 2017

KEYNOTE SPEAKER

S01 Our journey to the cave – adventures by balloon

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We describe the collaboration of clinicians and anatomists to validate a novel approach in the treatment of trigeminal neuralgia.

Balloon rhizolysis of the trigeminal ganglion is an established procedure whereby a needle is passed into the foramen ovale (FO), a Fogarty balloon is fed into Meckel's cave (MC), and the ganglion is compressed by inflating the balloon. Placement of the balloon is routinely guided by anatomical landmarks and X-ray. The gold standard is to achieve a pear-shaped outline of the balloon in MC. Placement, however, can prove difficult and may even result in inadvertent damage to surrounding structures such as the carotid artery, temporal lobe, cavernous sinus, and adjacent cranial nerves.

We investigated electromagnetic neuronavigation to provide improved 3D guidance for balloon rhizolysis using cadaveric specimens. The bulk of the work was done by Biomedical Science undergraduates as part of their Honours project (Megan Lonie, Iona Pimentil, Vlad Iliescu, Edward Bader, Neerjhor Pervez).

Ethical statement: All cadaveric material was donated to the University of Aberdeen in accordance with the Anatomy Act 1984 and the Anatomy Act 1984 [as amended by the Human Tissue (Scotland) Act 2006].

The first study aimed to confirm that placement of the needle was accurate. Seven cadaveric heads initially underwent CT scan. Images were uploaded onto a StealthStation S7 neuronavigation system (Medtronic Inc., Minneapolis, MN, USA). Each specimen was registered with the guidance system. The FO was identified and targeted bilaterally. A 1.9 × 110 mm needle (Menghini Biopsy Set, Aspen Medical, Redditch, UK) with AxiEM™ stylet (Medtronic Inc.) was used to place the tip of the needle through the FO and 4 mm beyond the skull base. Indocyanine Green 0.25 mL (Cardiogreen Sigma-Aldrich Company Ltd, Dorset, UK) was injected (the dead space of the needle was 0.2 mL). Each specimen was then dissected, and the location of the dye recorded. Eleven of the 14 injections resulted in deposition of dye in MC. Two had no dye found and one had ectopic dye. When dye was present it was found staining the mandibular nerve (V3) in 10 of 11 specimens and in the ganglion adjacent to V3 in 6 of 11. In two specimens the dye spread much wider to include the rest of the ganglion and trigeminal nerve. Variations in the presence of dye and its spread were felt to be due to the technical difficulty of injecting such a small volume with the equipment used.

The second part of the study examined anatomical changes that occur with inflation of a Fogarty balloon when placed with EM guidance. Four further cadaveric specimens were dissected, removing the brain and tentorium but maintaining the dura over the middle cranial fossa. Needles were guided into the FO bilaterally by the same method. A 4 French Fogarty catheter (Edwards Lifesciences, Irvine, CA, USA) was passed down the needle such that the balloon at the tip (16 mm) lay within MC. Video recording of the changes occurring while the balloon was inflated were taken. All eight needle placements accurately guided the catheter into MC. The dural layers were clearly heard peeling apart as the balloon inflated up to a volume of 0.8 mL. Our concern that the catheter could enter the posterior fossa was not borne out, as we found that the catheter would curl up within MC rather than pass through the trigeminal porus when pushed further than 16 mm.

This work provided sufficient confidence in the technique to proceed to use it clinically. Twenty-two operations have now been performed with excellent early clinical outcomes.

YOUNG INVESTIGATOR

S02 Human neck extension and tracheal exposure in relation to open tracheostomy

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Open tracheostomy is traditionally performed at the second and third tracheal rings under moderate neck extension to optimise visibility and access to the trachea. As cervical spinal pathology may limit flexion and extension, the risk of overextension is a concern for both surgeon and anaesthetist.

This study aims to describe the relationship between neck extension and tracheal exposure.

The trachea was dissected and exposed from cricoid to suprasternal notch in 39 cadavers in the Human Dissection Room at Cambridge University. The neck was flexed and extended at 15° increments between 45 and 135°, as determined by a goniometer along a vertical line joining the external auditory meatus and nasal ala relative to the horizontal plane of the supine body, with full flexion and extension being 0–180°, respectively. Digital calliper measurements were made of visible tracheal length and rings from cricoid to suprasternal notch.

Our results showed that the mean tracheal length gained from 45–135° extension was 29.6 mm (SD 8.9) in all subjects, with the

mean number of tracheal rings exposed being 2.95 rings (SD 1.23) The mean tracheal length (and number of visible rings) at 45°, 60°, 75°, 90°, 105°, 120°, and 135° was 28.8 mm (6.0), 29.2 mm (6.1), 32.3 mm (6.6), 38.0 mm (7.1), 45.1 mm (7.7), 50.6 mm (8.1) and 55.7 mm (8.6), respectively. For an individual subject, the mean increase in length (and visible rings) between 45–60°, 60–75°, 75–90°, 90–105°, 105–120°, and 120–135° was 14.9% (9.5%), 12.6% (11.6%), 19.3% (10.7%), 22.0% (10.4%), 17.9% (6.9%), and 13.7% (6.6%), respectively. In conclusion, we demonstrated the maximum percentage change in tracheal length was elicited between 75 and 105°, with the maximum change in number of visible rings between 60 and 90°. Although increased tracheal exposure continues up to 135°, the above data suggest that neck extension of up to 105° is likely to yield a reasonable length for open tracheostomy, especially for those patients for whom further neck extension may pose unacceptable risks.

Ethical approval was not required for this study as consent was obtained from all donors prior to decease for anatomical education, training and research.

S03 Utilisation of suture material in the production of dynamic prosections in the Thiel-embalmed human cadaver

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The Thiel-embalmed human cadaver has many strengths in the teaching of functional anatomy to students due to its flexibility, which allows dynamic simulation of muscle activation. However, this is restricted in areas where surrounding structures limit either access or visualisation of the desired movement, an example of which, is the extrinsic muscles of the eye, where the bony orbit restricts access and student visualisation of the muscles. We describe our experience in the use of suture material in the generation of dynamic prosections, where traditional fixation methods have struggled with the technical requirements to display functional anatomy. We found that the muscle belly was poorly suited to the tensioning muscle attachments, possibly due to the generation of fenestration within the myocytes during the fixation process, whereas the tendinous insertions provided good reproducible suture anchoring for the generation of tension when a modified Krakow stitch was applied. This was noted even with the delicate tendons of the extrinsic muscles of the eye. The longevity of a 5-0 prolene stitch was sufficient to be utilised for prosection generation, which allowed production of cadaveric prosections displaying both functional and dysfunctional anatomy that until recently could not have been conceived. Student feedback indicated that this method of demonstrating functional anatomy was well received.

Ethical permission for the evaluation part of the study was obtained from the university's ethical committee. Generation of the prosections falls under the ethical remit of anatomical examination; additional ethical permission is not required.

S04 Anatomical investigation of the ileocaecal junction in cadaveric specimens

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The ileocaecal junction (ICJ), located where the terminal ileum enters the caecum, is important in preventing caeco-ileal reflux. However, its precise nature remains unclear, with descriptions alternating between 'valvular' and 'sphincteric' or a combination of both mechanisms. This study aimed to investigate the morphological and functional features of the ICJ in 33 embalmed cadaveric specimens. The terminal ileum was observed to enter the caecum on its medial aspect in most cases ($n = 25$), anteriorly in five specimens, and posteriorly in three specimens. The mean angle between the distal terminal ileum and ascending colon was 106° (SD 23.0°). Similar to published literature, the internal appearance of most of the ICJs could be classified as labial ($n = 19$), but 12 were papillary-type. Two morphologies (tube-like and rosette-like) have not been described previously. Papillary ICJs had significantly thicker lips (mean = 3.56 cm) than labial ICJs (mean = 1.76 cm), whereas labial ICJs were longer horizontally than papillary ICJs ($P < 0.05$). In 24 specimens, a transition zone, the 'vestibule', was present between the caecal and ileal walls, and had a mean depth of 2.21 cm. A vestibule was present in a larger proportion of labial ICJs (18/19) than papillary ICJs (4/12). Caecal folds were noted on either side of the ICJ opening in 26 specimens, with only one or absent folds in the remaining cases. When air was pumped into the ascending colon with the specimens submerged in water, the caecum perforated in four cases without the occurrence of caeco-ileal reflux. These ICJs were deemed to be competent, suggesting that mechanical factors may contribute significantly to ICJ function. These findings provide additional quantitative and qualitative detail to existing descriptions of the ICJ, and indicate a degree of variation beyond current classifications. Demonstration of possible competence in cadaveric specimens without neuronal input also lends support to a potential intrinsic valvular mechanism for the ICJ. No ethical approval was required for this study and consent was obtained from donors.

S05 Variations of the circumflex humeral arteries: human cadaveric study

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Surgery is the main treatment option for both anatomical and surgical neck humeral fractures, which could result in damage to the circumflex humeral vessels. The aim of this study was to identify the variational patterns of the anterior and posterior circumflex humeral arteries. Cadaveric bodies (three males, two females: average age 68.8 years) were obtained from the University of Edinburgh anatomy department, regulated by the Human Tissue (Scotland) Act 2006. A total of 10 shoulders were dissected. A full exposure and record of the axillary artery and its branches was performed. The anterior and posterior circumflex humeral arteries were observed to arise as single branches from the third part of the axillary artery in only 70% of specimens ($n = 7$). In one cadaver, the posterior circumflex humeral artery (PCHA) arose from the subscapular artery on one side (10%, $n = 1$) and from the profunda brachii artery on the contralateral side (10%, $n = 1$). In the remaining 10% ($n = 1$) the anterior circumflex humeral artery (ACHA) was found as a branch of the PCHA, with the latter being a direct branch of the third part of the axillary artery. In all the specimens, the ACHA coursed laterally, posterior to both the short head of biceps brachii and coracobrachialis, to reach the surgical neck of the humerus. In 90% ($n = 9$) of the specimens, the PCHA passed posteriorly through the quadrangular space, whereas in 10% ($n = 1$), after arising from the profunda brachii artery, it ran superolaterally between the long and lateral heads of triceps towards the surgical neck of the humerus to anastomose with the ACHA. Knowledge and awareness of these variations is essential not only to suspect, diagnose and treat possible complications of common fractures and dislocations in the region, but also to prevent iatrogenic injury.

S06 Does virgin coconut oil mitigate testicular injuries in rats following alcohol use in highly active antiretroviral therapy?

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The consumption of alcohol by people living with HIV/AIDS is associated with a graver prognosis. Long-term use of

antiretrovirals may have certain health challenges that may be aggravated by concomitant alcohol use. This study investigated virgin coconut oil (VCO) as an adjuvant to the deleterious effects of highly active antiretroviral therapy (HAART) and alcohol on the cytoarchitecture and functioning of the testis. Forty adult male Sprague-Dawley rats, weighing 165–176 g, were divided into eight groups and treated according to a protocol which was approved by the Animal Ethics Committee with protocol reference number 'AREC/087/015D'. Testicular histology, stereological parameters, seminal fluid, testosterone, luteinising hormone (LH), follicle stimulating hormone, the antioxidant marker malondialdehyde (MDA) and antioxidant glutathione (GSH) were examined. The use of ethanol alone and ethanol + HAART showed extensive degeneration in the seminiferous epithelium, decreased semen quality, disorganised basement membrane and widened, hypocellular interstitium. GSH was significantly decreased in the ethanol-alone treated group with no significant effect on testosterone, LH, and MDA levels. Adjuvant treatment with VCO at low dose (2.5 mL kg⁻¹ bw⁻¹) improved sperm motility with a partial restoration of the histopathological alterations. High doses of VCO (5.0 mL kg⁻¹ bw⁻¹) showed greater improvement with respect to sperm counts, increased GSH antioxidant levels and a well preserved testicular cytoarchitecture.

S07 3-Dimensional tractography of the human extracranial facial nerve course using diffusion-weighted MRI imaging

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Imaging of the facial nerve in its extracranial course, especially as it courses through the parotid gland, has historically been difficult to achieve. There are many potential advantages of 3D radiological visualisation of the facial nerve tract. Diagnostically, the facial nerve could be assessed for its relation to parotid pathology, both benign and malignant. In the pre-operative setting, this new technology could allow surgeons to plan surgical approaches and techniques, of which there are many, in order to best avoid inadvertent damage to the facial nerve and/or its branches. New advances in diffusion-weighted magnetic resonance imaging (DW-MRI) scanning, processing and reconstruction techniques may allow accurate mapping of the facial nerve on its extracranial course. Our feasibility study aimed to establish an *in vivo* reproducible DW-MRI protocol to replicate the course of the extracranial facial nerve from its exit through the stylomastoid foramen to its five terminal branch divisions. High angular resolution diffusion imaging (HARDI) DW-MRI scans were undertaken at 3 Tesla in four subjects (voxel size 2x mm³ isotropic in 61 directions with multiple b-values = 400/800/1500 s mm⁻¹). Following pre-processing and T1/T2 image registration, constrained spherical deconvolution tractography was undertaken with multiple step-sizes and angle thresholds. Two cadaveric scans were also performed using the same scanning and tractography protocol and repeated at a reduced voxel size (1.2 mm³ isotropic) for increased resolution. Each cadaveric facial nerve was subsequently dissected out for

anatomical localisation and comparison with the scans. Various scanning parameters were compared to reveal the DW-MRI protocol yielding the most reliable extracranial course of the facial nerve *in vivo*. Successful anatomical correlations with the cadaveric scans suggest the validity of our approach in principle. Future directions include refinement of our scanning parameters with greater numbers and further validation with intra-operative anatomy.

Ethical approval was sought and obtained by the research and management boards of the Neuroscience Institute and the Anatomy Department of Trinity College Dublin for imaging and subsequent dissection of donated human cadaveric material. Both cadaveric donors had consented for the purposes of medical study, research and teaching within Trinity College Dublin.

KEYNOTE SPEAKER

S08 Human embryology: why should we study it, new approaches and re-emerging importance of anatomical knowledge

Susan Lindsay

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Congenital disorders are a significant burden on human health. Moreover, it is becoming clear that many disorders that manifest later in life also have a basis during fetal stages. Understanding the developmental origins of such disorders is the key to developing potential therapies. However, it is often difficult to study and interpret human developmental data, as most developmental processes involve complex changes in size, shape, and structure. We have been using a series of digital 3D models to visualise and interpret gene expression data as a means both to identify and characterise subregions of organs as they develop and to investigate possible functions of the genes themselves. At a more global level, in recent years there have been several studies aiming to characterise changing fetal transcriptomes in human, initially at the level of whole organs or their subregions and now at the level of single cells. Powerful new 'omics approaches ultimately rely on having a spatial context for where the tissues or cells were obtained. Moreover, data are generated from multiple samples and by different laboratories. To analyse and interpret these data effectively there will need to be a 'common co-ordinates framework' for human embryo and fetal development, a goal that requires anatomical knowledge to underpin and enable comparisons from one sample to another, across developmental stages and between species.

The MRC/Wellcome-Trust funded Human Developmental Biology Resource at Newcastle University (HDBR) collects human embryonic and fetal tissues, with appropriate maternal written consent and approval from the Newcastle and North Tyneside NHS Health Authority Joint Ethics Committee. HDBR is regulated by the UK Human Tissue Authority (HTA) and operates in accordance with the relevant HTA Codes of Practice.

YOUNG INVESTIGATOR

S11 Understanding the trabecular architecture within developing human lumbar vertebrae

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The human lumbar vertebral column plays an important role in the transfer of load to the pelvic complex, with vertebral trabecular bone architecture aligning along principal stress lines. This architectural arrangement has been studied extensively in the adult; however, there is a paucity of information regarding the development of this biomechanically important trabecular network. The aim of this research was to quantify the developing trabecular architecture within the human lumbar vertebral column from the fetal period to 4 years of age, using non-invasive micro-computed tomography (μ CT). In this study, 22 L5 lumbar vertebrae between 28 weeks *in utero* and 4 years of age were scanned using μ CT to visualise and quantify the trabecular architecture within the vertebral centrum. Twenty-seven volumes of interest (VOIs) were identified within each centrum and classified based on their anatomical position. Fetal and perinatal specimens were found to have a significantly higher number of plate-like trabeculae that were less well spaced compared with the 0- to 2-year and 3- to 4-year age cohorts. The thickest trabeculae were found in the perinatal and 3- to 4-year age cohorts. A significant increase in trabecular thickness between the fetal and perinatal period was observed, followed by a decrease between the perinatal and 0- to 2-year age cohort and a second significant increase into the 3- to 4-year age cohort. The decrease in number and volume of trabeculae between the perinatal age cohort and early infancy corroborates the theory of constructive regression, whereby bone resorption unlocks excess nutrients stored during the fetal/perinatal period while there is no biomechanical requirement for weight-bearing. Furthermore, although the 3- to 4-year age cohort does not yet seem to mirror the adult structure, increasing trabecular thickness and significant differences between central and peripheral VOIs imply that development is occurring in relation to increased load. No ethical approval was required.

KEYNOTE SPEAKER

S14 Using transgenic mice to understand the anatomical basis of tactile allodynia

David I. Hughes

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Chronic pain remains a major unmet clinical problem. This condition affects 20% of the European population; however,

only two-thirds of chronic pain patients respond to the treatments currently available. The need for more effective pain management strategies is therefore clear. One major barrier to developing novel treatments is our limited understanding of spinal cord circuits. The aim of my work is to identify individual neuronal components of discrete sensory circuits, and then determine whether/how these change in chronic pain states. This basic science approach to understanding fundamental elements of dorsal horn circuits provides us with a means of identifying potential new targets for therapeutic benefit.

Low-threshold mechanoreceptive afferents (LTMRs) normally convey innocuous tactile information into the central nervous system. The release of neurotransmitter from their central terminals is under strict presynaptic control, mediated through inhibitory presynaptic (axo-axonic) synapses. This provides a mechanism where the barrage of mechanosensory input can be gated and prioritised directly, helping us initiate contextually relevant responses to our environment. Work from my laboratory has identified a neurochemically defined population of spinal interneurons as a source of such presynaptic inputs on to LTMRs, and subsequent studies have shown that the loss of inhibition mediated by these cells underpins the development of mechanical sensitivity seen in tactile allodynia, where previously innocuous touch is perceived as painful.

In this presentation, I will describe a series of multidisciplinary experiments we have carried out that help explain how innocuous tactile inputs can activate pain circuits under pathological conditions. These are essentially basic anatomical studies looking at synaptic connectivity in the spinal dorsal horn, but also incorporate state-of-the-art technologies in molecular genetics, *in vitro* electrophysiology, and optogenetics to enable us to tackle fundamental questions of synaptic connectivity, and how these change in chronic pain states.

All experiments were approved by the Ethical Review Process Applications Panel of the University of Glasgow and were performed in accordance with the European Community directive 86/609/EC and the United Kingdom Animals (Scientific Procedures) Act 1986. Recovery surgical procedures were carried out using isoflurane anaesthesia. Terminal anaesthesia was induced by overdose using sodium pentobarbitone. This work was supported by the BBSRC (grant BB/J000620/1).

YOUNG INVESTIGATOR

S15 Developing tools for the manipulation of BMP signalling during late cerebellum development in the chick

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The cerebellum is a highly foliated structure at the posterior of the brain, responsible for co-ordination and fine motor control. The cerebellum contains a large proportion of the total neurons in the brain, the most abundant of these neurons being the granule neurons. During development, these neurons leave the cell cycle and differentiate from granule cell progenitors in the external granule layer of the cerebellum into granule cell

neurons found in the internal granule layer. Although there is abundant evidence suggestive of a role for BMP signalling in this process, functional studies *in vivo* have proved difficult to achieve, owing to the late formation of the external granule layer during development. To overcome this, we aimed to manipulate the BMP signalling pathway with a novel inducible system that uses the Tol-2 transposase to incorporate inducible constructs into the chick genome. We designed and constructed a vector expressing an SMAD inhibitory transcription factor, SMAD6, known to disrupt BMP signalling. Introduction of this construct into the developing embryonic chick cerebellum using *in ovo* electroporation will allow the effects of manipulation of the BMP signalling pathway to be observed and therefore the role of BMP signalling in granule cell neurogenesis to be explored.

No ethical approval was required for completion of this research.

S17 Haemodynamic alteration in the chick causes aberrant TCF21 expression and coronary vascularisation

Chrysostomos Perdios, Kar Lai Pang, Matthew Parnall and Siobhan Loughna

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In embryonic development, the epicardium is essential to form a normal functioning heart. Epicardial derived cells contribute to the heart as it develops, including fibroblasts and vascular smooth muscle cells. Previous studies have shown that a heartbeat is required for epicardium formation. Further, preliminary studies from our laboratory have shown that the development of the epicardium is aberrant when the haemodynamics are altered. This study aims to investigate how the epicardium and some of its derived cell lineages respond to altered haemodynamics in the developing embryo. As the aetiology of many congenital heart defects is unknown, we suggest that an alteration in the haemodynamics of the heart might provide an explanatory basis for some of them. To change the haemodynamics, outflow tract banding (OTB) using a double overhang knot was performed on HH21 chick embryos, with harvesting at HH35. A number of genes involved with ECM and coronary vascular development were analysed by qPCR. Further, immunoblotting was performed on cadherin proteins and the fibroblast marker TCF21. In addition, immunohistochemistry was performed against smooth muscle actin to visualise the coronary vessels. From qPCR analysis, the HH35 OTB hearts showed changes in genes involved in collagen deposition and angiogenesis. Immunoblots at HH35 showed a downregulation in TCF21 but no change in cadherin expression. The immunohistochemistry results showed fewer vessels in the interventricular septum and a higher myocardial wall-to-lumen ratio in HH35 OTB hearts. In conclusion, these studies suggest that changes in haemodynamics can cause aberrant coronary vascular formation and changes in collagen deposition. Future studies will involve immunohistochemistry on the TCF21-positive cells and collagen I.

All works in this study are Schedule 1 procedures and have been ethically reviewed at the University of Nottingham. All procedures and facilities are compliant with local and institutional guidelines.

KEYNOTE SPEAKER**S18 The benefits of the Thiel cadaver for testing and training in regional anaesthesia**

Graeme McLeod

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Ultrasound-guided regional anaesthesia is a needle-based intervention whereby local anaesthetic is deposited around nerves, limbs anaesthetised for major surgery, and general anaesthesia and even sedation avoided. Our group has conducted a series of studies on the soft embalmed Thiel cadaver investigating its role as a simulator of regional anaesthesia. We initially showed physical fidelity and functional alignment: both elasticity and strain (a unitless entity indicating the relative displacement of fluid) were consistently similar to that of human beings. Elasticity allows cadaver tissue to expand and then relax rapidly as injectate disperses from target sites. This property allied to remarkable durability has provided ideal conditions for device testing and regional anaesthesia simulated training. Devices tested include echogenic needles and a piezo-actuated visible vibrating needle, invented in Dundee and soon to be commercialised as a biopsy needle. Testing of new 40 MHz micro-ultrasound transducers used by our group to investigate the mechanisms of nerve damage in pigs is to be repeated on the Thiel cadavers in March. High-fidelity simulation has also allowed us to teach using the latest educational methods such as mastery learning while measuring performance. Our eye-tracking studies on the Thiel cadaver in a stable, dedicated practice environment with operator feedback showed a degree of construct validity and discriminatory validity not otherwise possible. We were able to show differences not only between experts and novices, but also within experts! We will soon be conducting a study using eye-tracking methods to quantify differences in novice learning curves using a standard needle and new needle from B. Braun and Philips that tracks the needle tip in colour. This is a regulatory study to be presented to the Federal Drug Administration (FDA). We are also hoping to obtain funding to validate the educational role of the cadaver in regional anaesthesia. We wish to quantify learning on the Thiel cadaver compared with standard training, then compare the mode of delivery (mastery learning vs. standard learning). The Thiel cadaver provides ideal simulation conditions and we have linked-up with the MSc in regional anaesthesia at the University of East Anglia so that MSc students can obtain practical training from a UK faculty.

S19 Integrating anatomy into the clinical dental undergraduate curriculum

Michaelina Macluskey

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Anatomy is an essential component of the dental curriculum, providing the basis for physical examination of the head and neck, interpretation of imaging of the teeth and adjacent

structures, delivering anaesthetic and performing surgical procedures. The dental curriculum is changing, with a focus on integrating the basic sciences across the clinic years and introducing patient-centred teaching at an earlier stage. This change is in part due to the fact that when students begin treating patients they have difficulty recalling basic anatomy knowledge learned much earlier in the course and lose the ability to apply it clinically. Unfortunately, for a number of reasons, there has been a decline in the time allocated to teaching anatomy. In many dental schools the traditional teaching method of cadaveric dissection has been replaced with prosection, living or surface anatomy, plastic anatomical models, and computer-based materials. In a small number of schools, students are taught on Thiel-embalmed cadavers, which are ideal for teaching applied clinical dentistry including local anaesthesia, dental extractions, surgical dentistry, and dental implants. There is great potential for dental students to benefit from an integrated, hands-on approach to anatomy of the head and neck, particularly in areas such as the distant spread of infection from an odontogenic focus, causing potentially fatal complications, the function of the temporomandibular apparatus, and understanding of the pattern of metastatic spread from oral cancer. With the growth of implant dentistry and the widespread use of cone beam CT imaging, there is a need for dentists to have a detailed knowledge of anatomy. In this area, cadaveric models are an ideal model to master the skills of sinus lift surgery, and soft and hard tissue grafting. This presentation will focus on potential anatomical solutions to dental problems.

No ethical approval was required for this study.

YOUNG INVESTIGATOR**S20 Peer-assisted formative assessment in neuroanatomy: an innovative approach for providing timely feedback on learning performance**

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Feedback is an important component of undergraduate medical education which gives students the opportunity to identify weaknesses and address them in time for assessments. Providing feedback to a large cohort in a timely manner can be challenging. However, near-peer teacher (NPT)-led sessions give the opportunity to offer feedback more frequently. One such session, as trialled at the University of Southampton, involves the use of an online live quiz throughout an undergraduate anatomy module for 2nd-year medical students. The aim of this study is to evaluate the popularity of these sessions and the performance across the learning objectives for the anatomy module. The head, neck, and neuroanatomy module consists of 4 weeks of prosection-based practical anatomy classes. In each week, an optional lunchtime session was offered to all 2nd-year medical students testing

knowledge from the preceding week's practical session. We compared performance in the Kahoot quiz between questions based on the learning outcomes for each of the practicals on the module. On average, 56 students attended each session. Of 127 votes, 91% of students rated the sessions positively. In total, 76 questions were asked covering 30 of the 43 learning outcomes for the anatomy module. The best answered topics ($\geq 80\%$ correct answers) were the skull, neuroanatomy (brainstem and subcortical), and thyroid gland. The poorest answered topics ($<50\%$ correct answers) were on the tongue, floor of the mouth, nasal cavity, pharynx, neck, and ear. Student NPT-led Kahoot feedback sessions proved to be a useful method of formative assessment for students and allows them to benchmark their progress at regular intervals. This feedback is unique in that it is delivered by peers and therefore creates a more relaxed environment to discuss problem areas and address learning needs. It is unclear whether these sessions had any impact on student performance or confidence.

No ethical approval was required for this study.

S21 Using quick response codes to combine online digital media with traditional anatomy teaching methods

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In 2016, global internet usage on mobile devices overtook desktops for the first time. Many students are searching for videos from websites such as YouTube on their mobile devices. For educators, it is important to find new ways of interacting with learners that provide a student-centred experience. Despite this, most students still prefer having a physical textbook over a digital copy. It is important to blend both aspects in a way that meets student needs. Quick response (QR) codes are a computer-generated matrix barcode which creates an optical label, linking directly to specific online content. The barcode can be carefully integrated into resources that support face-to-face teaching. We chose to integrate QR codes into both lecture-slides and the neuroanatomy practical booklet to support teaching with cadavers. This evaluation comprised a single cohort ($n = 250$) of year 2 medical undergraduates on a neuroanatomy module.

IN all, 46 QR codes were scanned 719 times during the module. Mobile phones were the most popular platform (76.7%). Sotonbrainhub videos used for the QR codes were rated as excellent by most (69.1%) students. The most popular video was the skull base. Student opinion on the use of the QR codes in the anatomy booklet was indifference to whether or not it was useful (median 3/5, SD 1.07). There was a weak positive correlation (+ 0.24 SpRho) between QR codes ratings and the ratings of the videos used ($P < 0.01$). The results of this study show that students do access video resources via QR codes when they are blended with traditional resources. However, many students were indifferent to their incorporation, suggesting they might prefer to direct the search for specific video content themselves. Students may also prefer to watch video content from desktop/laptop computers, negating the need for QR codes, which are purely intended for smaller mobile devices.

No ethical approval was required for this study.

S22 Tutor perception of student engagement regarding task-based learning in medical anatomy

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Interactive tasks or 'games' are increasingly used within medical education: the principal goal is neither amusement nor pleasure – rather employment of different tactics to stimulate learning through novel means. Several such games are employed throughout the teaching of anatomy at the University of Bristol. This designed game, focused on the anatomy of the respiratory system, ran during teaching in the Human Dissection laboratory and was facilitated by four Anatomy Demonstrators. Complete bony thoraces were wrapped in cling-film to allow partakers to draw pleural markings and fissures onto the skeletons while considering their clinical importance. Instructions regarding task completion and intended learning outcomes were provided to participants. The task was used for two cohorts at different stages of their medical career – 2nd year medical students (Yr2) and 2nd year foundation doctors (FY2). Students worked in groups of five to complete the assignment. We then ran a focus group of anatomy staff to review participant engagement in the task. Good engagement was observed in both undergraduate and postgraduate groups; however, differences were seen in the form that engagement took. Yr2 students approached the task cautiously: they were reluctant to mark the specimens and appeared to spend longer considering task instructions prior to action. In contrast, FY2s were more assertive: they prioritised task completion over accuracy of markings. Our findings correlate with current literature, suggesting there are differences in the approach of undergraduate and postgraduate groups to interactive tasks. Future work should acknowledge this diversity when devising and implementing such games and consideration should be given to make these sessions effective.

This project was a teaching evaluation tool; a research ethics review was not required, but good ethical principles were adhered to throughout.

S23 Study of variations in profunda femoris artery and its circumflex femoral branches in Thiel-embalmed cadavers

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Studying the possible variations of the profunda femoris artery and its circumflex femoral branches will guide surgeons and other health professionals during surgical and radiological procedures. The study investigated variations in the vascular patterns of origin of the profunda femoris artery, the medial circumflex femoral, and the lateral circumflex femoral artery in 20 (7 males and 13 females) Thiel-embalmed cadavers of the Centre for Anatomy and Human Identification (CAHID). Distances were measured between the origin of the PFA and

midpoint of the inguinal ligament, between the origins of the MCFA and PFA and from the origin of LCFA to the origin of PFA. Data was analysed with IBM SPSS. The PFA mainly originated from posterolateral aspect of the FA and the PFA was found to also originate from the anteromedial side of the FA. The medial and lateral circumflex femoral arteries originated from the PFA with incidences of 47.5 and 87.5%, respectively. In clinical practice, an awareness of PFA variations will help during radiological interventions, to define vascular patterns, during orthopaedic procedures in the femoral region such as hip replacement, and is also a basic requirement during femoral artery puncture to minimise cases of severe secondary bleeding. All work was performed according to the Human Tissue (Scotland) Act 2006, therefore the ethical requirement was met.

S25 Predicting optimal central venous catheter length from surface measurements in adult humans

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The length required for optimal positioning of a central venous catheter (CVC) within the distal superior vena cava (SVC) is variable between patients and must be estimated during insertion. However, this estimation is frequently incorrect, resulting in misplaced CVCs, poor catheter function, cardiac arrhythmias or even cardiac perforation. This study aimed to determine which of several surface measurements was most closely correlated with optimal CVC length. The distance between several anatomical landmarks was measured on 40 embalmed cadavers. Measurements included: height; suprasternal notch to xiphisternum, umbilicus, and pubic symphysis; and right sternoclavicular joint (RSCJ) to the ipsilateral costal cartilages (CCs). A thoracotomy was then performed, CVC guidewires were inserted via the right internal jugular vein 2 cm above the RSCJ, and – confirming position by direct observation – a minimal and maximal length between which each tip lay within the SVC was recorded. The maximal length of each CVC within the SVC was significantly correlated with the distance between the RSCJ and the ipsilateral 4th CC, 5th CC, and their midpoint ($P < 0.001$, $P < 0.002$, $P < 0.001$). A CVC inserted a length equal to the distance: (1) between the RSCJ and the 4th CC would lie in the SVC in 38/40 (95%), the right atrium (RA) in 0/40, but the distal third of the SVC in only 2/40 (5%); (2) between the RSCJ and the 5th CC would lie in the SVC in 35/40 (87.5%), the distal third of the SVC in 23/40 (57.5%), but the RA in 5/40 (12.5%); and (3) between the RSCJ and the midpoint of the 4th/5th CC would lie in the SVC in 40/40, the RA in 0/40, and the distal third of the SVC in 13/40 (32.5%). These findings provide a clinically relevant guide for CVC length, depending on the perceived relative importance of placement within the distal SVC and/or avoiding placement within the RA.

No ethical approval was required for this study as each donor had consented to the use of their body for anatomical education, training, and research prior to decease.

S26 Exploration of surgical anatomy and mastoidectomy using mixed reality (HoloLens) – a new surgical education tool for ENT trainees

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Mixed reality (MR), a tool used to supplement the real world with virtual objects, is increasingly available for medical education. Microsoft's invention of HoloLens allows the user to experience MR using a head-mounted device without interfering with their physical reality. This study aims to design a new training MR application for the surgical anatomy of the temporal bone and the mastoidectomy procedure, replacing the surgical simulator. The project involved collaboration of seven students from five academic disciplines (medicine, anatomy, medical art, forensic art, and computing science), collaborating with Medtronic, a large biomedical company, to design an application. ZBRUSH, UNITY, MAYA, and SIMPLYGON were used to develop the temporal bone model and software. The following modules were designed: Basic HoloLens Tutorial, Temporal Bone Surgical Landmark Exploration, Free Drilling of the Temporal Bone, and Real Time Step-by-Step Mastoidectomy Surgical Experience. The HoloLens tutorial allows the user to accommodate to the MR environment. A 3D view of the temporal bone allows users to orientate and understand the anatomical relationship between otology structures. Free drilling of the temporal bone highlights the facial nerve in relation to other anatomical structures and allows users to explore the temporal bone from different angles and planes. The mastoidectomy tutorial provides a step-by-step guide to perform the surgery in a surgical plane simulating a surgical experience. Shader surface deformation replicates a real-time bone drilling experience. The teaching of anatomy to trainees is limited due to restricted availability of cadaveric temporal bones. MR aims to introduce another teaching modality that can help trainees orientate, navigate, and understand the complex 3D bony and soft tissue anatomy of the temporal bone. This educational tool provides a 3D MR learning experience for the exploration of temporal bone anatomy. We aim to test the tool among ENT trainees and incorporate a shared hologram learning experience in the future. No ethical approval was required.

S27 Blood supply and innervation of the prostate in humans: improving clinical outcomes of radical prostatectomy

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Radical prostatectomy (RP) is the main choice of surgical treatment for prostate adenocarcinoma, often leading to subsequent problems with erectile function and urinary incontinence as a result of damage to nearby neurovascular structures. Here, we provide an update on our efforts to generate a refined map of neurovascular structures supplying and neighbouring the prostate, in order to better protect these structures during surgery and improve clinical outcomes following radical prostatectomy. The cadaveric bodies were obtained from the University of Edinburgh anatomy department, regulated by the Human Tissue (Scotland) Act 2006. Detailed dissection of two embalmed male pelvis was performed employing a novel approach designed to preserve the entire prostate *in situ*, while reliably tracing and identifying neurovascular supply to the prostate and corpora cavernosa. Our initial observations suggest that the accessory pudendal artery, branching from the internal pudendal artery, was the main source of arterial supply to the corpora cavernosa. Arterial supply to the prostate was primarily derived from the superior and inferior vesical arteries. We are proceeding with parallel attempts to map the related innervation of the prostate and neighbouring structures.

S28 A high-density EMG investigation of changes in human erector spinae activity during an endurance task

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Chronic non-specific low back pain (LBP) is internationally recognised as a leading cause of disability, with an annual cost to the UK health services of between £1.5 and £2.8 billion. People with LBP display changes in muscle behaviour which may contribute to the persistence of symptoms. Developments in the field of electromyography (EMG) have led to high-density electromyography (HDEMGM) systems which may provide new insights into changes in muscle activation in people with LBP. This study aimed to investigate these changes during a lumbar muscle endurance task.

Thirteen people with chronic LBP and 13 healthy controls participated in this study, which was approved by the University of Birmingham Ethics Committee. Muscle activity was recorded with two grids of electrodes (13 × 5) placed bilaterally over the lumbar erector spinae (ES), positioned 2 cm lateral to the L5 spinous process. Participants completed a timed endurance test of supine isometric back extension until task failure (drop in

trunk height of > 10°) and muscle activity was recorded with HDEMGM simultaneously.

People with LBP had significantly lower endurance (LBP: 186.2 ± 72.3 s, controls: 283.0 ± 33.0 s; $P < 0.01$). With time to task failure normalised, preliminary HDEMGM analysis indicated that the amplitude was systematically higher in control participants ($P < 0.05$) than in LBP participants on their most painful side. There was no difference in mean frequency (MNF) of the EMG signal between groups; however, the centre of activity of the EMG amplitude map was, on average, 12 mm more cranial for the LBP group over the duration of the task.

These results show comparable myoelectric manifestations of fatigue of the ES for people with and without LBP despite differences in endurance time. The participants with LBP showed relatively greater activation of the cranial region of the lumbar ES compared with control subjects, indicating a different motor strategy for the task.

Ethical approval for this study was granted by the University of Birmingham Ethics Committee, and all experiments were performed with the full understanding and informed consent of the participants.

S29 Advanced diffusion MRI tractography and the stria medullaris: awaking anatomical research into the human dorsal diencephalic conduction system and neuropsychiatric disorders

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The dorsal diencephalic conduction system (DDCS) allows diverse basal frontal areas to influence dopaminergic and serotonergic tone. It achieves this by integrating frontal, striatal, septal, and hypothalamic inputs to the habenula through the stria medullaris (SM). The habenula, in turn, has direct connections to the raphe nuclei and dopaminergic midbrain. The habenula and SM are inconsistently visualised with neuroimaging, resulting in a paucity of *in vivo* research into the DDCS. Diffusion-weighted imaging (DWI) allows neuronal pathway reconstruction by inferring tracts from the diffusion properties of hydrogen protons. We present an anatomically validated and reliable protocol for rendering the SM with DWI.

Eight human cadaver brains were examined for uniformity of anatomical relationships, length, curvature, and diameter of the SM. From this, a DWI tractography Boolean logic gate protocol was deduced with emphasis on reproducibility, crossing white matter tract proximity and anatomical consistency of anterior and posterior boundaries. Thirty subjects were scanned using high angular resolution diffusion imaging (61 directions, b -value 1500 mm², Philips 3T Achieva) as part of the ongoing REDEEM study. Following higher order modelling whole brain tractography, two independent raters isolated the SM using the protocol. Each tract was checked, examined, and cleaned for extraneous streamlines by the rater and a neuroanatomist.

The SM was reconstructed with excellent inter-rater reliability (P -value 0.88 between raters). Tracts also exhibited consistent

tract diffusion metrics (P -value 0.92). Comparing diffusion-rendered tracts with anatomical measurements suggested satisfactory face validity of the technique. This is the first study showing reliable DWI reconstruction of the SM. Moreover, cadaveric measurements provided evidence towards formulating a DWI tract protocol and its validation.

Identification and quantification of the SM will advance DCCS research and its role in neuropsychiatric disorders including depression, schizophrenia, anxiety, chronic pain, and addiction. This technique showed good inter-rater reliability and face validity as a novel approach to delineating the SM using diffusion-weighted imaging.

Ethical approval was obtained from Tallaght Hospital/St James Hospital Joint Research Ethics Committee as part of the REDEEM study.

S32 Thiel cadaveric models for cardiovascular device design and training

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Medical implantable devices are often tested in animals during the initial research and development phase, as well as during the safety trials which are required for regulatory approval in different parts of the world. In addition, animals are used for training clinicians in new procedures. Live animal experiments on medical devices currently require large animal experimental models, usually pigs, dogs or sheep, as does operator training on new cardiovascular implants. During the development phase of cardiovascular devices, formalin-preserved human bodies or fresh cadavers cannot be used, as the blood vessels or cardiac chambers are clotted and blood flow is needed for realistic testing; again, live animal experiments are often carried out. It has been recently recognised that an alternative embalming process, developed by Walter Thiel, provides an improved model for testing and training which is becoming more widely recognised. Our early work in the cardiovascular field has shown that it is an excellent solution for cardiovascular device testing and training, as the large blood vessels (arteries and veins) are patent, and flow can be introduced to simulate living blood flow. This has the potential to significantly reduce the use of animals for such testing.

No ethical approval required for this study.

S33 Plastinating Thiel-embalmed human cadaveric specimens – using alternative dehydration solvents to aid in the preservation of colour and flexibility

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The flexibility and lifelike qualities possessed by cadavers which have been Thiel-embalmed have allowed innovative research and teaching of gross anatomy to undergraduate and postgraduate students at institutes across the world. However, there are no current publications outlining the methods used to

plastinate Thiel-embalmed prosections to ensure their long-term preservation. Following standard S10 plastination of Thiel-embalmed cadaveric hand specimens, substantial changes were observed in the colour and flexibility of the specimens, the most drastic of which were following acetone dehydration. Therefore exploration into an alternative solvent for dehydration was deemed desirable. The following solvents were tested to replace acetone; methylene chloride, acetonitrile, methanol, and acetic acid. Preliminary studies involved submerging small 1 x 1 cm cubes of skin and adipose tissue to monitor the solvents effectiveness as a dehydration solvent and to observe changes in tissue structure and colour. Further analysis of plastinated specimens using alternative dehydration solvents was then undertaken. Colour changes were analysed at specific landmarks on hand specimens using RGB values in PHOTOSHOP. Changes in flexibility were assessed using extension and angle analysis obtained before and after dehydration utilising a custom-made rig. From the analysis of colour changes and differences in flexibility exhibited by Thiel-embalmed cadaveric hands, results suggest that methylene chloride and acetonitrile are more effective at preserving colour and flexibility as compared with standard methods utilising acetone. From the results of this study it is proposed that when plastinating Thiel-embalmed cadaveric specimens, methylene chloride or acetonitrile be used to aid in the preservation of tissue colour and flexibility. No ethical approval was required for this study.

S34 Sexual dimorphism and ethnic variance: their impact on the reliability of the antlingula as a landmark in human mandibular surgery

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The antlingula is a prominence located on the lateral aspect of the mandibular ramus, arising as a consequence of the attachment of the masseter. Its clinical significance relates to its potential use as a surgical landmark to prevent iatrogenic damage to the inferior alveolar nerve (IAN) during intra-oral vertical ramus osteotomy (IVRO). This osteotomy is performed from the lateral aspect of the mandibular ramus, which precludes direct visualisation of the nerve. Although variation in the incidence and location of the antlingula is recognised, no comprehensive studies have previously been conducted with the aim of evaluating the relationship between the antlingula, mandibular foramen, and lingula in different populations and sexes. In this study, 478 dry hemimandibles from eight different geographic populations were used to map the relationship between the lingula, antlingula, mandibular foramen, and midwaist point of the ramus on each hemimandible.

This study was conducted on specimens held by the Duckworth Laboratory at the Leverhulme Centre for Human Evolutionary Studies in Cambridge. Skulls were sexed by discriminant analysis of visually assessed sexually dimorphic traits. Positional relationships were determined by digitising nine anatomical landmarks per hemimandible.

The antilingula was successfully located in 100% of hemimandibles. Mean inter-observer discrepancy in locating the antilingula was 0.59 mm. No significant sex difference was identified in the spatial relationship between lingula and antilingula. This relationship, and the relationship between the antilingula and mandibular foramen, showed multiple differences between geographic populations. Irrespective of geographic location or sex, the mandibular foramen was less than 5 mm posterior to the antilingula in 90.4% of cases. This study suggests that the antilingula may be used as a reliable surgical landmark to predict the location of the IAN, and that osteotomy 8.6 mm posterior to this point will avoid damage to the IAN in 98.8% of cases.

No ethical approval was required for this study.

S35 Constructive regression in the juvenile human ischium: a qualitative analysis

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Despite the growing literature base examining juvenile bone development, the stimuli which guide early bone architecture have not yet been established. This study aimed to describe potential factors underlying the development of the human ischium through an analysis of ontogenetic patterns through the late fetal and juvenile periods.

Digital radiographs of 98 juvenile human ischia between the ages of 28 intra-uterine weeks and 16 years of age were collected and processed using a four-colour gradient mapping function (Adobe PHOTOSHOP). Patterns in radiographic intensity were then analysed in relation to major developmental milestones to determine potential guiding stimuli.

Three gross developmental stages were identified. The fetal and neonatal ischium were characterised by a progressive increase in bone intensity with advancing maturity. Between 5 months and 3 years of age, however, radiographic bone intensity was found to decrease markedly across the entirety of the ischium. From 2 to 16 years, bone intensity was found to increase. Specific trajectories developed in the acetabular margin and posterior aspect of the body.

The progressive increase in bone intensity during the fetal and early postnatal period is indicative of a steady accumulation of ossified tissue, perhaps due to the relative abundance of calcium available prior to weaning. The resorptive period during infancy coincides with a rapid expansion in ischial volume and also the onset of weaning, which may restrict calcium availability. Following the conclusion of the infant growth spurt at approximately 3 years of age, the deposition of bone appears to mirror the positions of increased bone intensity in the adult, suggesting that this development is a mechanically guided response following the principles of bone functional adaptation. The period of 'constructive regression' during infancy appears to allow the release of calcium to facilitate rapid growth, while also establishing a 'blank slate' for subsequent biomechanically responsive bone development.

Ethical approval: Specific ethical approval was not required for this study due to the historic/anatomical nature of the collection studied.

S36 Variation of the brachial artery: human cadaveric study

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Bifurcation of the brachial artery into radial and ulnar arteries generally takes place in the cubital fossa. However, a higher origin of the radial and ulnar arteries could be mistakenly identified as a basilic vein for venous access; therefore, identification of high bifurcation and the course of the brachial artery is of anatomical and clinical importance in multiple medical procedures of the upper limb, including surgeries, cardiac catheterization, cannulation, angiography, Doppler ultrasound, and blood pressure measurement. The aim of the current study is to investigate the brachial artery and its branch variations. The cadaveric bodies were obtained from Anatomy, University of Edinburgh, regulated by the Human Tissue (Scotland) Act 2006. A total of 10 upper limbs (three males, two females: average age of 68.8 years) were dissected with a full exposure and record of the brachial artery and its branches. The brachial artery was observed to follow its classical origin, course, and branches in 70% ($n = 7$), whereas in 30% ($n = 3$) in two male cadavers, bilateral in one and left-sided in the other, it was found to bifurcate into radial and ulnar arteries midway in the arm, both of which coursed down into the cubital fossa and then followed their classical anatomical courses in the forearm and hand: no other variations were observed in their courses or branches. Trauma, surgical procedures or even invasive vascular procedures could pose life-threatening risks if the physician is unaware of the variation; therefore, knowledge of such anatomical vascular variations is of a high clinical importance.

S38 Human cadaveric study of accessory head of flexor pollicis longus: Gantzer's muscle

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Gantzer's muscle is an accessory head of flexor pollicis longus, which could potentially cause median nerve or anterior interosseous nerve compression; therefore, its variations and relations to these nerves are of clinical importance. Five cadaveric bodies (three males, two females: average age of 68.8 years) were obtained from the University of Edinburgh Anatomy department, regulated by the Human Tissue (Scotland) Act 2006. A total of 10 upper limbs were dissected. A full exposure and record of the anterior and posterior compartments of the arm and forearm were performed. Gantzer's muscle was identified in 40% of the specimens (four right-sided forearms), arising from the medial epicondyle of the humerus and attaching to either the flexor pollicis longus muscle ($n = 2$) or its tendon ($n = 2$) with a mean muscle length, width, and thickness of 44.8, 5.7, and 2.4 mm,

respectively. In all the specimens, Gantzer's muscle intervened between the median nerve and its muscular branches anteriorly, and the anterior interosseous nerve and ulnar artery posteriorly. The presence of such variation could participate in common entrapment syndromes and injuries of the median and anterior interosseous nerves. The current study was limited by the small number of cadavers; therefore, further investigation is recommended into whether the unilateral presence of Gantzer's muscle is correlated to dominant hand side.

S39 Virtual 3D models of the human brain to enhance neuroanatomy teaching

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Cadaveric specimens are still the most realistic and detailed resources for learning anatomy. However, their use for teaching neuroanatomy is often limited as they lack texture and colour differences between different brain parts, making identification of structures difficult. Digital 3D atlases enhance the teaching and learning of neuroanatomy, but currently available digital tools have some shortcomings, e.g. models are idealised, the level of detail cannot be adjusted, and user interaction with the models is limited. To overcome this, we developed virtual 3D models of the human brain that can be animated and easily modified for different curricula. 3D models of six key parts of the human brain were created using a magnetic resonance imaging (MRI) scan of a human head and 3D image processing software. We created animations of the models and incorporated the models into 3D PDFs. Due to the high resolution of the MRI scan used, our models are very detailed and allow the study even of small structures. The 3D models have been used to teach students of medicine and biomedical sciences at the University of Aberdeen and have received very positive student feedback. These models allow more user interaction than the 3D neuroanatomy atlases currently available to students at the University of Aberdeen and have the advantage of being compatible with our 3D screens for stereoscopic visualisation. Our bespoke 3D models therefore enhance teaching as they have several advantages over current commercial 3D neuroanatomy atlases and can be modified to suit different courses and degree programmes. No ethical approval was required for this study.

S40 Anatomical society syllabi project: Delphi process for a nursing core syllabus

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Bioscience is an umbrella term used by nurse educators to describe anatomy, physiology, biochemistry, pathology, pathophysiology, genetics, microbiology, pharmacology, and

biophysics as an amalgam. Primary studies have identified a 'bioscience problem' throughout the UK regarding a deficit in student nurses' and registered nurses' knowledge, understanding, and application of the biosciences. There is no clarity on which specific bioscience subjects are problematic for students. The bioscience deficit in nursing has been attributed, in part, to national widespread variability within the curriculum. To address the existing gap and gain a consensus on UK national standards within anatomy education for undergraduate nurses, the researchers adopted a modified Delphi approach to facilitate the creation of an advisory syllabus for nursing undergraduates. The Delphi method has since gone through cycles of popularity, scrutiny, adaptation, and refinement based on a pragmatic need to structure group communication in specific disciplines. The presentation critically examines the anatomy syllabi project-modified Delphi technique that has been distributed nationally using comparative analysis of how the Delphi technique has evolved for MBChB, Pharmacy and Nursing. Each project has utilised a similar approach yet minor adaptations have evolved in response to discipline-specific considerations to further refine the method. Using a post-positivist perspective, we critically examine the advantage of using a narrative scale with open, closed, and general comments rather than a numerical scale with optional comments for constructing subject specific learning outcomes. We also address the need for multidisciplinary 'experts' in a preliminary pilot panel where expertise is highly variable as exemplified in allied healthcare disciplines.

My ethics reference number is NURS021, granted by the Department of Health and Social Science, University of Edinburgh. Our method used informed consent and participant information that explicitly stated the right to withdraw at any time.

P01 Normalised periprostatic fat using MRI can predict high-grade prostate cancer after controlling for pelvic cavity dimensions

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Several studies have described an association between obesity and prostate cancer (PCa). More recently, normalised periprostatic fat volume (NPFV) was found to be a significant predictor of having high-grade PCa. The aim of this study was to assess the influence of the pelvic cavity size obtained from MRI, to identify any covariance of NPFV and pelvic cavity size in 162 men who underwent radical prostatectomy for clinically non-metastatic PCa. The anteroposterior diameter of the pelvic inlet (API), pelvic depth (PD), and pelvic outlet (PO) were measured on T₂-weighted sagittal MRI slices. Interspinous distance (ISD) was measured on a T₂-weighted axial slice. Pelvic cavity index (PCI) was subsequently calculated (PCI = API * ISD / PD). Periprostatic fat volume was measured on sequential T₁-weighted axial slices from the level of the base of the prostate

to its apex using a segmentation technique, then normalised to prostate volume to account for the variations in prostate size (NPFV). Abdominal fat area (AFA) and subcutaneous fat thickness (SFT) were measured on T₁-weighted axial slices at the level of the umbilicus and the upper border of the symphysis pubis, respectively. Participants were stratified into two groups: low-grade PCa (Gleason score ≤ 6) and high-grade PCa (Gleason score ≥ 7). Propensity score analysis was conducted. There was a statistically significant difference between the mean NPFV of the low-grade (1.89 ± 0.78) and high-grade (2.48 ± 1.1) PCa [$t(42) = -2.03, P = 0.049$] groups after controlling for age and PCI. There was no relationship between NPFV, other fat measures, body mass index (BMI) or any of the pelvic cavity measures. There was no relationship between PCa grading and BMI, SFT, AFA, ISD, PD or PO. In conclusion, NPFV can predict high-grade PCa after controlling for pelvic cavity dimensions and could therefore be a valid marker for high-grade disease. This is a study with Caldicott institutional approval (Caldicott/CSAppGN021211). No ethical approval was required for this study.

P02 Morpho-functional changes in cardiocytes of rats with induced type two diabetes: effect of natural cocoa

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Altered structure and function of the myocardium in diabetes mellitus have been ascribed to oxidative stress arising from the combined effects of hyperglycaemia, hyperlipidaemia, lipotoxicity, and insulin resistance. Structural or functional changes that are not directly attributable to confounding factors such as coronary artery disease (CAD) or hypertension, constitute diabetic cardiomyopathy. As natural cocoa improves insulin sensitivity and possesses potent antioxidant properties, it was hypothesized that cocoa would attenuate structural changes consonant with diabetic cardiomyopathy. This study aimed to investigate the protective potential of natural cocoa on heart muscle microstructure in rats with induced type 2 diabetes. Forty-five normoglycaemic male Sprague–Dawley rats aged 15–18 weeks were randomly placed into two groups: diabetic ($n = 35$) and non-diabetic ($n = 10$). Type 2 diabetes was induced by sequentially injecting nicotinamide and streptozotocin intraperitoneally. Confirmed diabetic rats were randomly put into three groups of 10 animals: diabetic untreated, diabetic treated with metformin, and diabetic fed with aqueous cocoa. Blood was sampled for fasting blood glucose and biochemical markers for oxidative stress. Randomly selected rats were sacrificed at midway and the end of the experiment and their hearts harvested for histomorphometric assessment of myocardial damage using design-based stereology. Animals were anaesthetised by ether inhalation and, when unresponsive to foot pinprick, they were euthanised by intracardiac perfusion with 10% buffered formalin. Variables for structural damage, as well as indicators of biochemical injury, were significantly lower in the diabetic rats fed cocoa than in diabetic untreated animals. In most cases, variables assessed were comparable or better in diabetic rats fed natural cocoa than in those given standard

metformin treatment. It is concluded that voluntary cocoa consumption attenuated structural and functional myocardium damage in type 2 diabetes.

Ethical approval was given by the University of Ghana College of Health Sciences Ethical and Protocol Review Committee.

P03 The history of human flexor tendon repair approaches in hand trauma

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During early surgical history, there was no distinction between tendon and nerve; thus Galen (129–210 AD) warned against tendon repair, as this would result in severe pain and convulsions, likely owing to an unintentional suturing of a lacerated median nerve. In the 10th century AD, the Persian surgeon Avicenna first recommended tendon repair after laceration or rupture. Such was the dominance of Galen's misconception that tendon repair did not become commonplace in Europe until the 17th century, by surgeons Roger of Parma and Roland of Milan. During the renaissance, surgeons in France and Italy began reporting successes of tenorrhaphy; however, flexor tendons of the hand were not described. Bielsalski reported the first successful flexor tendon graft in 1910, with detailed understanding of the anatomical and surgical principles. In 1918, Bunnell described primary tendon repair in Zone II of the finger, but reported adhesions and loss of function, leading to the technique falling out of favour. Direct suture repair did not become commonplace until the 1960s, after Verdan reported comparable results to tendon transfer. Since then, improved anchoring methods, improved suture material, and early rehabilitation have resulted in significantly improved clinical outcomes. No ethical approval required for this study.

P04 Perfused human Thiel-embalmed cadavers – the solution to the endovascular device and methodology training gap

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The field of endovascular technology continues to grow with a plethora of new devices and techniques providing improved patient experiences and outcomes. To support the continued growth of this field, there is a need for both pre-clinical testing and training models to develop, assess, and train those using these advanced technologies. Currently, animal models and benchtop testing do not meet this need, particularly because of vasculature anatomy, i.e. vessel calibre, branching, blood flow, etc. Thiel-embalmed human cadavers provide realistic anatomy, tissue flexibility, and colour. The addition of extracorporeal perfusion to their patent vascular system, coupled with multi-modality clinical imaging, offers an unparalleled model for endovascular training, and medical device testing and training. The purpose of our

research was to develop perfused cadaveric models and evaluate them either for teaching or for device assessment purposes. Over a 5-year period, 17 training courses using perfused cadavers in full clinical simulation of an interventional suite, have been conducted in fields such as stroke treatment with mechanical thrombectomy, basic interventional radiology skills, advanced interventional radiology – liquid embolization, CT guided ablation, intra-ventricular pacemaker procedure, and neuro-intervention are exemplars. In addition to training, prototype medical devices such as endo-arteriovenous fistula devices, stents, and stent-grafts have undergone pre-clinical evaluation using the perfused Thiel cadaveric model. The evaluation of these models has demonstrated that they are robust, reliable, and adaptable enough to meet the ongoing needs of interventional radiologists' training requirements as well as commercial medical device manufacturers' needs for pre-clinical testing models.

All cadaveric research was conducted in compliance with the Anatomy Act (Scotland) 1984. Ethical approval for research studies was obtained through the Thiel Advisory Committee, University of Dundee.

P06 The use of Thiel-embalmed cadavers in medical research

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Current models for testing human medical devices and training staff in their use include animal models lacking sufficiently similar anatomy and benchtop models lacking the haptic feel of human tissue. Thiel-embalmed cadavers offer an anatomically appropriate model with similar haptic characteristics to live human tissue. In addition, patent vasculature permits the introduction of extracorporeal flow. This cadaveric model can be used to simulate clinical scenarios for training and device testing, offering the opportunity to obtain pre-clinical data on the deployment and performance of medical devices. The current study describes an example, investigating the forces exerted upon a lower limb arteriovenous connection device during daily activities. This medical device aims to restore blood flow to an ischaemic lower limb, pertinent to diabetic patients at risk of developing lower limb vasculature changes, leading to limb ischaemia and potential amputation. For this study, applications of flow were achieved through 12Fr ports in the femoral artery and vein, and 14–18G veniflons in the medial plantar veins. For outflow, 4Fr and 6Fr ports were placed into dorsalis pedis and the medial plantar artery, respectively. The flexibility of Thiel-embalmed cadavers allowed the lower limb to be placed in various positions that represented functionally relevant positions of daily activity. A contrast bolus was injected into each femoral vessel individually, enabling vascular visualisation through fluoroscopy and digital subtraction angiography, and validating the patency of the model in each position. This model was used for deployment of an endovascular stent creating an arteriovenous connection between the posterior tibial vessels, followed by CT scanning in each position. The Thiel cadaveric model allowed an image-guided interventional procedure to be mimicked, and permitted acquisition of quantitative data of forces exerted upon the stent. This is required for device design, approval, and implementation in healthcare.

No ethical approval was required.

P07 Dodge vs. traditional embalming: experiences of anatomy technical and teaching staff at Trinity College Dublin

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Dissection and learning from prosections using human body donors continues to play an important role in educating students from various disciplines in human anatomy at Trinity College Dublin (TCD), Ireland. Cadaveric anatomy allows us to teach anatomy with a practical 'hands on' approach and various embalming techniques allow us to preserve donor bodies in order to achieve this. At TCD, the traditional formalin-based embalming technique and, more recently, the Dodge embalming technique have been used. Formaldehyde was introduced as a preservation technique in 1893 and since then has been widely utilised to good effect. However, in recent years, 'soft embalming' techniques have been employed. The aim of these techniques is to achieve a more colourful, flexible, and mobile donor body allowing for more realistic dissections. This is particularly relevant to surgical trainees as well as anatomists, as it provides a more accurate representation of human tissue.

The aim of this communication is to illustrate our departmental experience with the Dodge embalming technique in contrast to the traditional technique by looking at its educational value as well as technical practicality.

The experience of the technical and academic staff of the TCD anatomy department with the Dodge and traditional embalming techniques was assessed through a questionnaire and semistructured interviews. When taking into consideration practicalities such as technical difficulty, cost, health, and safety risk to staff, we have found that the Dodge embalming technique is superior or equal to the TCD traditional solution. However, complications with mould formation in the Dodge-embalmed donors have cost technical staff time and have caused restrictions in usability. Looking at the educational value, we view the Dodge technique as a viable complement to the TCD solution going forward. It was found to be suitable for dissection/prosection of delicate areas such as the anterior neck, hands, and feet, whereas the TCD solution seems to be superior for larger muscular areas. It has proven to be very suitable for surgical training courses due to the flexibility of the tissue. However, the TCD solution smell has been more acceptable to students. Difficulties regarding the longevity of the Dodge preservation make its future as a preservation technique at TCD questionable. Continued assessment, with particular attention to longevity and internal organ preservation, is required to assess the feasibility of embalming a higher proportion of donors with the Dodge embalming technique. Institutional ethical approval was not required.

P08 Social Media Mentor Club – an ethical method to investigate how medical students are using social media

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Medical students and doctors are at risk of being suspended from their duties due to unprofessional social media use. Guidelines on how to use social media professionally are provided to medical students by the General Medical Council (GMC) and British Medical Association (BMA). Medical schools usually direct students to these guidelines in Year 1 or 2. It remains to be seen how effective this method and the guidelines themselves are at encouraging medical students to use social media professionally. As overt lurking on medical student's social media profiles was not considered ethically viable as a method to investigate whether students use social media professionally, the researcher met with the ethics committee at Brighton Sussex Medical School to discuss how an ethical approach to carry out this work could be achieved. An approach involving both the researcher and medical students co-investigating students' use of social media, was approved. This action research-based co-investigation aimed to foster active learning around professionalism on social media, with a view to participants becoming social media mentors, hence the Social Media Mentor Club (SMMC) was formed.

Eleven Year 1 or 2 medical students signed up to the SMMC and met weekly for 6 weeks. Club members gave written consent for their social media profiles to be searched by other club members and for their social media behaviour to be judged against the guidelines. Club members reported their findings back to the entire group to facilitate collective active learning. Club members also studied and summarised the main guidelines provided by the GMC and BMA. Memo notes and reflective pieces created by club members throughout the club term were collected by the researcher.

The findings suggest that there is a need for more guidance on how to use social media professionally, rather than warnings on how not to use it.

P09 Re-living anatomy: medical student use of lecture capture

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Lecture capture resources offer students the chance to 're-live' the anatomy lectures online, within the student central platform to improve and consolidate their learning. These resources are thought to be particularly useful for medical students given they are required to gain an extensive knowledge of anatomy in relatively short periods of time when compared with other university degrees. The study objective was to investigate how Lecture Capture aided student learning. An online survey invited 405 medical students in years 1–3 to participate, achieving a 24.7% response rate ($n = 100$). Results suggest Lecture Capture to be useful to student's learning, understanding concepts, and improving performance in assessments and, despite a concern over lecture recording affecting attendance records, attendance remained constant. Students in particular found the live recorded lectures and practical demonstration sessions most useful. Interestingly, 74.2% of students preferred to view certain sections of the

recordings selectively as opposed to the full lectures. The most common reasons to view the lecture recordings was to help with difficult material not fully understood and to generate more complete lecture notes. In summary, Lecture Capture provides students with a positive opportunity to further develop their learning.

Ethical approval was granted by The Brighton and Sussex Medical School Research Governance and Ethics Committee (RGEC). The students gave informed consent for participation in the study.

P10 Development of an interactive e-resource using 'The Edinburgh Stereoscopic Atlas of Anatomy'

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At Cardiff University, students learn anatomy through a blended approach utilising online resources and cadaveric dissection/prosection. The use of cadaveric material provides students with an important haptic, interactive experience; it also allows them to appreciate and visualise anatomy in three-dimensions (3D). Given that learning acquired by dissection is best examined using a similar modality, our assessments utilise prosected specimens in the form of spot tests. However, for students, access to cadaveric specimens is limited due to restricted University hours and heavy use of the facility. This makes self-study using specimens difficult. As a result, many students use textbooks and online videos to supplement their knowledge, and although this is useful, these resources are neither authentic nor comparable to the specimens used in the exam. Our aim was to develop an interactive resource that utilised anaglyphs created from 'The Edinburgh Stereoscopic Atlas of Anatomy'. To evaluate what type of resource the students wanted, a multidisciplinary focus group was created and drove its design. Anaglyphs of the atlas were produced using AFFINITY PHOTO™ and the tutorial created using ARTICULATE STORYLINE™ software. A trial of the resource was completed and sent out to a large focus group of Biomedical Science and Dental students studying anatomy as part of their degree, along with a Likert-like questionnaire for evaluation of the resource. The results obtained were positive, with students rating the resource highly and strongly agreeing that they would use it in the future. Our future directions are to develop the resource further, creating interactive videos on key anatomical principles, introducing a point scoring system for gamification, and creating question banks that mimic exam conditions.

No ethical approval was required for this study.

P11 Game-based virtual learning environment for human anatomy teaching

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Virtual learning environments (VLEs) are digital platforms for supporting students' learning and assessing their performance. Anatomy VLEs facilitate student learning by providing remote access to teaching materials (e.g. digital anatomical models) outside of practical classes but they often possess notable shortcomings, e.g. there is limited interaction with models and the VLEs are rarely engaging enough to maintain student interest and promote learning. Combining gamified learning with high-resolution 3D models of anatomical structures can enhance VLEs for anatomy teaching. In a previous study, we developed and evaluated a prototype VLE of a game-based heart anatomy learning tool that received very positive student feedback. In this study, we aimed to expand this VLE with other aspects of heart anatomy. We created a high-resolution 3D model of a cadaveric human heart using photogrammetry, then optimised it along with a model obtained from a free online anatomical database, and integrated both into the VLE. Games were designed to emphasise interaction, requiring the player to turn, click, and study the model on screen in order to succeed. Several features were considered for adding challenge to the games. An Anatomy class was surveyed to gauge student interest in Anatomy VLEs and potential features for this project. Participants responded positively to using VLEs and indicated a willingness to try new virtual tools in future. A working prototype was developed, suitable for testing with a larger sample. Two games were fully implemented: heart orientation and MRI cross-section identification. Each game aligns with one or more heart anatomy learning outcomes. This prototype is now ready to be developed further to encompass a wider range of anatomical regions.

This study was approved by a Licensed Teacher of Anatomy. No other ethical approval was required. We are grateful to the individuals who facilitated this cadaveric study by their generous body donations.

P12 Augmented and virtual reality in anatomy education: a review

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A recent shift in many medical school curricula in the UK has resulted in faster progression to clinical exposure and significant reductions in allocated anatomy teaching, thus educators have adapted to using novel technologies to complement existing teaching methods. Virtual reality (VR) and augmented reality (AR) are emerging technologies which use headmounts, headphones, and motion sensors, combined with software-generated images to demonstrate content to users. In anatomy education, VR and AR allow users to select an area of anatomy and interact with it by 'dissecting' through layers and to rotate the field of view to examine the structures, read related text or listen to short audio clips. Reviewed studies indicate VR and AR technologies help to increase spatial understanding of the relationship between anatomical structures, and have had positive qualitative feedback related to the student learning experience. These technologies may offer a valuable addition to traditional anatomical teaching methods such as cadaveric dissection by reinforcing and improving understanding, and

increasing student engagement in self-directed learning by using the technology.

No ethical approval was required for this study.

P13 Stripping off for anatomy: student attitudes on the use of ultrasound in pre-clinical medical education

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Living anatomy with ultrasound imaging has been taught in pre-clinical medical education at Brighton and Sussex Medical School (BSMS) for several years. Handheld ultrasound is used increasingly in clinical practice and clinicians consider it important to incorporate it into early medical education. Quantitative studies have shown its value among medical students; however, qualitative studies of student views are missing from the literature. This study set out to determine student attitudes towards living anatomy with ultrasound. Medical students in their 2nd to 4th year accustomed to ultrasound anatomy teaching were invited to audio-recorded focus groups facilitated by an anatomy demonstrator. Thirteen students attended the groups. The focus groups were approved by the Research Governance and Ethics Committee at BSMS. Subjects covered included feelings about undressing for learning, incidental pathological findings, and transabdominal pelvic ultrasound. Themes extracted from the transcribed audio revealed an acceptable expectation that the students would undress for the sessions, mixed views about those who routinely refused to undress (except for religious reasons), pressure on males to be the model (sometimes to the detriment of their education), body consciousness in younger females, and minimal concerns of finding pathology. Transabdominal pelvic ultrasound was acceptable to fewer students; the main concern was incidentally discovered pregnancy. The findings support stronger implementation of the expectation that each student will be the ultrasound model and consideration of the role of pelvic ultrasound in the curriculum. Limitations include the possibility that the small voluntary sample did not represent widespread student views, that the groups were facilitated by a BSMS anatomy team member who was known to some students, and that some opinions and stories were shared second-hand. In summary, students value living anatomy and ultrasound but feel they are missing out when being the model.

The students gave informed consent for participation in the study.

P14 A digital 3D dissection of the human forearm to enhance anatomy teaching

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At the University of Aberdeen, students learn Anatomy primarily in prosection-based practical classes. To facilitate the identification of structures in the prosections, students are encouraged to use labelled diagrams and dissection photos in Anatomy atlases and

textbooks (including a digital atlas accessible via our virtual learning environment). However, as these are 2D images of individual dissection stages, it remains difficult for students to understand complex 3D relationships in cadaveric specimens. The anatomy of the forearm is particularly challenging, as it includes 20 muscles organised in several layers, but digital 3D learning resources can facilitate the understanding of complex spatial relationships. To enhance our prosection-based teaching of forearm anatomy we therefore created and evaluated a new digital 3D learning tool showing the dissection of the human forearm muscles step-by-step.

We created high-resolution 3D models of a cadaveric forearm at different dissection stages using photogrammetry. We then animated these 3D models, highlighted muscles and added text labels. To evaluate this learning tool, we handed out questionnaires to 23 undergraduate Anatomy students.

Students found the 3D models realistic and highly detailed. They indicated that the digital dissection was more helpful than photographic and illustrated anatomy atlases to identify the muscles of the forearm in prosections and 90% of students agreed they would use it outside the anatomy lab, preferably from their personal laptop or PC. These results indicate that our digital dissection facilitates students' learning and improves student experience.

This study was approved by a Licensed Teacher of Anatomy. No other ethical approval was required. We are grateful to the individuals who facilitated this study by their generous body donations.

P15 Comparing staff and student neuroanatomy knowledge as a way to inform teaching practices

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Neuroanatomy is commonly perceived as a difficult topic, although some students choose to attend the annual National Undergraduate Neuroanatomy Competition (NUNC), which tests neuroanatomy beyond the level of the typical medical curriculum. One challenge of teaching anatomy to medical students may be to understand areas of weakness, as areas of perceived difficulty may vary between staff and students. The aim of this study is to compare staff vs. student performance data in the 2017 NUNC anatomy spotter examination.

In all, 109 students and 13 staff (neuroscientists, anatomists, neurologists, and neurosurgeons) completed the 84-part neuroanatomy spotter examination. All questions were assigned a subtopic (Cerebrum, Diencephalon, Cerebellum, Vascular, Brainstem/CN, Spinal Cord or Other). Student and staff scores were compared for each subtopic. Ethical Approval was not required.

Staff significantly outperformed students (72.3 vs 54.6%, $P < 0.05$). Of the 84 questions asked, the distribution of questions was 17 Brainstem/Cranial Nerves, 3 cerebellum, 30 cerebrum, 8 diencephalon, 11 other (mostly ventricular system, meninges, and skull), 3 spinal cord, and 12 vascular. Students performed best (> 60%) on diencephalon and other, moderately (50–60%) on spine, vascular, cerebrum, and brainstem/cranial nerves, and poorly (< 50%) on cerebellum. However, staff

performed best (> 70%) on spinal cord, other, and diencephalon, moderately (60–70%) on cerebellum, cerebrum, and vascular, and poorly (< 60%) on brainstem/cranial nerves.

Although staff outperform students in our neuroanatomy spotter, areas of relative strength and weakness differ between the two cohorts. Further study is required to facilitate teachers to understand areas of weakness and better direct their efforts to improve student knowledge and understanding.

Ethical approval was not required.

P16 Usage and perceptions of small group and online anatomical case-based learning

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Although a useful activity for the reinforcement of content knowledge and the development of critical thinking skills, the scheduling of dedicated small group tutorials to facilitate case-based learning is an increasing challenge with increasing class sizes and crowded curricula. Our own anatomy case-based discussions were originally designed for use within a small group setting, but we have adapted a number of these to an online eLearning format in recent years. Case-based eLearning activities, adapted from cases discussed within our anatomy small-group tutorials, were created incorporating instructional design principles such as interactivity, reinforcement and feedback. Following ethical approval (REC001085), we examined students' usage and perceptions of these aligned case-based activities, with regard to aspects such as enjoyment, usefulness, and feedback. Data were collected from two separate sources: (1) usage of the online case-studies from online logs and (2) anonymous survey responses. Students rated both of these case-based learning activities favourably, commenting specifically on aspects such as interactivity, feedback, and the clarity of the content. Although students appeared to rate the eLearning resource higher than the small-group case discussions, more students participated in these discussions than completed the online versions of the cases. In addition, our data suggest that those students who do complete these cases online tend to do so towards the end of the semester as a revision aide, instead of concurrently, when learning the corresponding content via lectures or anatomy room tutorials. Our data confirm that both case-based resources are a useful adjunct to anatomy teaching in either small-group discussions or as online eLearning resources. However, providing these as optional online activities does mean that some students will omit them from their study, and it should be taken into consideration from the outset whether the information contained within these activities should be core, or complementary, to the existing curriculum. Ethical approval (REC001085) was granted.

P17 Anatomy in an integrated medical curriculum: starting the conversation

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Whereas anatomy education is a thriving academic discipline, the focus on pedagogy with respect to non-clinical life sciences is often neglected within the broader field of medical education. Anatomy education often stands alone, with few links to the paedagogic research undertaken in other life sciences disciplines. As an anatomist and a genetics educator, respectively, we consider our own collaboration to be relatively rare. Basic science pedagogy can also be marginalised when compared with well-funded scientific research. We aim to start a conversation with anatomists and medical educators to emphasise the importance of life sciences education within medical training, as well as the significance of connections between anatomy and the other basic sciences. *MedEdPublish* is a recently launched open-access journal. We guest co-edited a themed *MedEdPublish* issue during spring 2017 entitled *Life Sciences in an Integrated Medical Curriculum*. Through this theme, we aimed to encourage dialogue surrounding the integration of anatomy and life sciences with respect to the following key areas: (1) learning gain, innovation, and teaching excellence; (2) research-led teaching and evidence-based practice; (3) integration and creating a community of practice; (4) student partnerships and preparing medical researchers. Here, we present our findings from this themed issue with a view to continuing the conversation regarding anatomy and life sciences education. We describe the articles published in our theme, our experiences of the editorial process and of the pioneering post-publication peer-review approach, in addition to our reflections on the facilitation of a conference workshop based around the theme. We have identified many examples of innovative and effective practice, with a view to further disseminating successful curricular integration of anatomical and basic sciences education to the wider life sciences and medical education communities.

Ethical approval was not required for this work.

P18 The Anatomical Society's core anatomy syllabus for pharmacists – a Delphi study

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This study utilised a modified Delphi method to develop the first anatomy syllabus for Masters of Pharmacy programmes

within the UK. The Delphi approach was employed to seek consensus on which learning outcomes should be included in such a syllabus. The Delphi method was modified, as the research utilised an existing framework of published learning outcomes rather than a blank canvas. The framework consisted of two iterations of the Anatomical Society core syllabus for regional anatomy in undergraduate medicine developed from McHanwell et al. (2007) and Smith et al. (2016). A Delphi panel was constructed involving 'experts' (individuals from different professional backgrounds with experience of teaching pharmacy students anatomy). Members of the Council and/or the Education Committee of the Anatomical Society nominated the panel members. The resultant panel consisted of 34 experts. The research team performed an initial screen of outcomes within the framework to remove outcomes that were obviously not applicable ($n = 10$); these typically related to clinical procedures. The Delphi panel completed the process online using the Survey Monkey platform. The experts were asked in two stages to 'accept' or 'reject' each learning outcome – stage one allowed for modifications to outcomes. A final formatting was performed by the research team to standardise presentation and make changes to correct any anatomical or minor syntax errors. In the first stage, 163 outcomes were presented to the Delphi panel; 53 outcomes remained after stage 1. Following stage 2, 50 learning outcomes formed the final syllabus. All learning outcomes on the new core syllabus achieved over 80% acceptance by the panel. These may act as a template for reviewing existing curricula or developing new ones. The resultant anatomy syllabus is the first for Pharmacists.

P19 Educator perspectives on anatomy education in a new medical curriculum

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A new medical curriculum has been introduced at Newcastle University for the first pre-clinical MBBS year, and will be rolled out in subsequent years to include the remaining 4 years of the undergraduate programme. Gross anatomy is currently delivered in lectures and dissecting room practicals using prosections; anatomy, microanatomy, and embryology are delivered using a variety of other physical and digital learning resources. The intention is to maintain and enhance anatomy learning modalities while increasing self-directed learning and, consequently, reducing length, and quantity of anatomy lectures and practicals. Anatomical content delivery has been designed around a clinical case-based approach, with Year One delivered in three foundation blocks of teaching, followed by 13 independent clinical cases (e.g. heart attack, hypertension, and liver disease). All anatomical learning outcomes (LO) continue to be delivered in cases across two pre-clinical years, in addition to all LOs relevant to the other basic sciences, as well as clinical and communication skills.

The anatomy LOs mapping against the Anatomical Society core syllabus, contact time, and number of sessions have decreased. Teaching is perceived by educators to have improved due to new facilities and resources, and smaller group sizes. Despite an

increased student intake, improved staff–student ratios have been accomplished through increasing session repeats with smaller groups. While certain improvements have been achieved, numerous challenges persist for anatomy educators when attempting to deliver the most effective student learning experience. We describe our initial perspectives on the first semester of anatomy teaching within the new medical curriculum at Newcastle, with a view to providing a more comprehensive overview following delivery of the entire pre-clinical phase at the end of the first year of delivery of the new curriculum in Summer 2018 and following the delivery of both pre-clinical years in Summer 2019.

Ethical approval was not required for this work.

P20 Historical anatomical artwork in the modern anatomy department

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Art and anatomy have had a close relationship throughout history. Indeed, evidence from the time of the ancient Egyptians reveals that anatomists were able to record their dissections through an artist's work, a practice which is still used today. Without this close relationship between anatomists and artists the medical profession would not have been able to share their knowledge as easily with others in the field, or as widely with the public. This relationship has therefore been critical in enhancing our understanding of the human body. Anatomy@Edinburgh holds an extensive anatomical art collection dating back to the early 19th century, including over 500 bespoke, large anatomical illustrations used for teaching in the pre-computer era. Therefore, the purpose of this project was to examine how displays of historical anatomical artwork can influence students and staff within an active anatomy teaching department. We have also investigated the importance of maintenance and display of artworks, with curated guidance, with regard to preserving historical artwork for future generations. We found that students have taken a keen interest in anatomical artworks being displayed, which has led to further discussions concerning how they would like to use art in their learning of anatomy. This has led to the creation of a new Anatomy@Edinburgh Contemporary Art Collection, featuring works from both professional and amateur artists (including students). We consider these developments to represent an important step forward in reinvigorating the relationship between art and anatomy, with benefits for students, staff, and the public. Due to the nature of this research, no ethical approval was required.

P21 Insights into the views of radiologists on anatomy education: more radiology, less cadaver!

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The reduction in teaching resources and increasing student numbers has led to reported inadequate anatomical knowledge of junior doctors, focusing on modes of pre-clinical anatomy education. We gauged the opinions of radiologists practising in Ireland regarding current and preferred teaching practices in anatomy. The majority of respondents (total 67) were qualified at consultant (67%) and registrar grades (31.8%), specialising in diagnostic and/or diagnostic and interventional radiology (98%). In all, 73% stated that radiology did not form a significant component of their undergraduate curriculum and 97% of respondents agreed that anatomy is central to the field. There was agreement or strong agreement among 82% of radiologists that radiology and anatomy should be taught in tandem during pre-clinical training, with 94% stating that complementing anatomy with radiological images would better prepare students for clinical practice. CT and MRI were the preferred imaging modalities for teaching anatomy, although free comments showed that all radiological imaging should be considered. Less than 50% of radiologists believed that the cadaver should remain the cornerstone of basic anatomy education, although it was seen as the preferred teaching tool (48%), followed by radiology and atlases. The majority of respondents (86%) felt that practising radiologists are best positioned to deliver radiology-based anatomy teaching to pre-clinical medical students. These data show that practising radiologists value anatomy education and the role of the cadaver as a teaching tool highly; however, opinion showed that anatomy education should be complemented by radiology, in particular MRI and CT imaging. Furthermore, radiologists feel that they themselves are best placed to teach clinically relevant anatomy. These findings show that radiologists are keen to be heard at pre-clinical levels offering clear insights into their views on the roles of radiology in anatomy education. These data may help inform the extent and delivery of radiology in the design and implementation of the anatomy curriculum in medical education.

P22 Clinical anatomy demonstrators add value to undergraduate medical and dental teaching and gain vital surgically relevant anatomical knowledge

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Following the General Medical Council's publication of *Tomorrow's Doctors* in 1993, and a restructuring of undergraduate medical curricula integrating basic and clinical sciences, anatomy education in UK medical curricula was drastically reduced. A variety of curricular additions, including early clinical and communication skills, marginalised anatomy education; the consequent reduction in contact hours and access to cadaveric teaching has led to the inevitable decline in graduates' applied anatomical knowledge. Unanimously, published data points to a worrying trend that graduates may now possess less anatomical knowledge than is considered safe for clinical practice. Consequently, recognising the value of anatomy in surgical careers, aspiring trainees vie for standalone

anatomy demonstrator posts outside traditional surgical training pathways. Several institutions recognise the range of expertise that trainees bring into the educational environment; the literature suggests that demonstratorships help trainees consolidate anatomy knowledge, and develop teaching and interpersonal skills, thus, ultimately, improving patient safety. Streamlined surgical training pathways allow little flexibility for the aspiring surgeon and make it challenging to step outside the training programme to take up standalone posts, although these result in greater surgically relevant knowledge and improved skills; demonstratorships are currently not formally recognised by the Royal College of Surgeons as core to surgical training, as they require time out of training. The evidence, however, points to the value of a sound foundation in anatomical education in developing clinical acumen. Demonstratorships arguably lead to competent and safe surgeons, whose anatomy foundations are rock-solid. Their value in role-modelling professional and ethical values to medical students, in addition to imparting anatomical knowledge to facilitate development of clinical reasoning capabilities, is undeniable. A review of the direction of surgical training, aiming to couple it widely with demonstratorships, must be a priority for surgical training programmes and educational institutions in order to continue to produce competent surgeons.

No further ethical approval beyond the remit of the Human Tissue Act was required.

P23 Should anatomy demonstration be a compulsory component of core surgical training?

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Anatomy demonstration is currently a non-compulsory component of core surgical training (CST), with only a few deaneries including it as a mandatory requirement at the 'Annual Review of Competence Progression' for surgical trainees. However, a thorough knowledge of anatomy is not only important for success at postgraduate membership examinations but is also essential for a career in surgery. At the University of Cambridge, there are 12 anatomy demonstrator positions linked to surgical on-call commitments at Addenbrooke's Hospital in six surgical specialties. This study aims to assess the opinions of a group of CST trainees regarding the value of anatomy demonstration within their training programme. At a regional intensive MRCS anatomy revision course, 19 delegates were asked to answer 20 pre- and post-course multiple choice questions taken from past examination papers to aid standardisation and to complete a post-course questionnaire. The grouped average results showed an improvement of 12% in their anatomical knowledge.

Analysis of the post-course questionnaire showed that the vast majority of delegates felt strongly that anatomy demonstration should be incorporated into the CST curriculum. The trainees were asked to rank the demonstration between 1 (not incorporated) to 10 (incorporated); the average score for the group was 8.8 (SD 2.3). Interestingly, when asked how

frequently they felt demonstrating should take place, over half the group (68%) considered this should be at least monthly. Although the numbers in this study are small, they represent trainees from a large deanery, and the results suggest that surgical trainees would embrace the inclusion of anatomy demonstration within their curriculum. Those who have chosen to take a year out of their training to do anatomy demonstration are able to improve their anatomical knowledge, develop teaching and research skills, and gain insight into what a surgical career involves from senior demonstrators on the teaching team. No ethical approval was required for the publication of this abstract.

P24 Collagen fibre orientation in the human temporal fascia

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Animal experiments and computer simulations suggest that the temporal fascia may play an important mechanical role in stabilising the zygomatic arch during mastication and contribute to the normal growth of the zygomatic arch by transferring forces to the bone. Measurements of these forces are difficult to obtain *in vivo* but collagen fibre orientation can provide useful information, as collagen fibres are aligned with the main force directions in connective tissues. In this study, we aimed to visualise and measure the collagen fibre orientation in the human temporal fascia to learn more about the mechanical forces that act on the fascia and the zygomatic arch.

Temporal fascia samples were extracted from three areas of superficial and deep temporal fascia in human cadaveric specimens. Samples were stained histologically for collagen and imaged with confocal microscopy. Images were analysed using IMAGEJ software to determine collagen fibre orientation.

We measured a predominantly superoinferior orientation of collagen fibres in both superficial and deep human temporal fascia layers. The 3D visualisation of selected sample areas suggested that the fibres have multiple orientations within each fascia sheet, similar to an interwoven network. In addition, we observed a large variation in the thickness of the fibres within and between the two fascia layers.

The predominant superoinferior orientation of the collagen fibres corroborates the hypothesis that the temporal fascia plays a role in stabilising the zygomatic arch during mastication by counteracting the inferior pull of the masseter muscle. However, the large variation of fibre orientation within the fascia layers suggests that the temporal fascia has to distribute forces in multiple directions.

This study was approved by a Licensed Teacher of Anatomy. No other ethical approval was required. We are grateful to the individuals who facilitated this cadaveric study by their generous body donations.

P25 An investigation into the morphology of the human inferior orbital fissure: using anatomical knowledge to inform the clinical management of orbital pathologies

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The inferior orbital fissure (IOF) is a space located in the floor of the orbit. Its anatomical location and shape is essential in the management of many orbital pathologies, and their surgical treatment.

The aim was to test the hypothesis that there is a statistically significant difference between the morphology of male and female IOFs, to investigate the quadrant location of the IOF within the orbit, and finally to develop a universal classification system that could be used clinically. A total of 85 skulls totalling 170 orbits were photographed using a Coolpix L330 Nikon camera at F4.2 zoom. The images were uploaded onto a computer and the software IMAGEJ was used to measure perimeter, longest length, widest length, and either the angle made at the superior medial point or if no angle was observed the narrowest width at this point. The results showed no statistical significant difference between sides or sex regarding the perimeter, longest length, widest width or narrowest width. The only statistical significant result was the difference in angle between male and female right skulls ($P = 0.0448$). All IOFs had some part located in the inferior lateral quadrant and 89.4% were located solely in this quadrant. Our classification system has four categories. Type 1 was observed 73.89%, type 2 in 7.23%, type 3 in 9.45%, and type 4 in 0.56%. A positive correlation between perimeter and longest length, and perimeter and widest width was also observed.

In conclusion, current data suggests that the morphology of the IOF is not statistically significant different between sexes or between sides. We also found the location of the IOF is usually found in the inferior lateral quadrant. Our classification allows four main variations to be accounted for, type 1 being the most common. This classification can be used when assessing orbital floor fractures.

Faculty of Medicine Ethical Approval: ID 9987.

P26 Human anatomical variations of sternocleidomastoid and their relationship to internal jugular venous cannulation

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The apex of the triangle formed by the clavicular and sternal heads of the sternocleidomastoid (SCM), Sedillot's triangle, is recognised as a landmark for internal jugular vein (IJV) cannulation. However, anecdotal evidence suggests that significant variation exists in the height and width of the triangle and its relation to the IJV. Previous research

demonstrated reduced the likelihood of successful cannulation on the left relative to the right. This study aims to describe anatomical variation in the heads of SCM and the relationship of Sedillot's triangle to IJV cannulation. The SCM was dissected in 41 cadavers in the Dissection Room at Cambridge University. Digital calliper measurements were taken. A marking pin was inserted perpendicularly at the apex of Sedillot's triangle to simulate IJV cannulation. The muscles were subsequently reflected to identify the position of the pin relative to the IJV. Results showed considerable variation in the clavicular distance between the heads, ranging from 0 to 67.6 mm, with a mean of 12.6 mm (SD 12.2 mm) and a mean triangle height of 35.2 mm (SD 14.7 mm). There was no significant difference in laterality. A pin inserted at the apex punctured the IJV successfully in most cases (left 23/40; right 33/40). Of the unsuccessful punctures, the IJV on both sides lay either lateral or medial to the apex. On the left, the mean distance from apex to IJV was 0.2 mm (SD 7.6 mm) with a range of 17.4 mm (lateral) and -14.8 mm (medial); whereas on the right, the IJV was lateral in most cases (mean 5.7 mm, SD 6.0 mm, range 13.9 mm and -2.3 mm).

In conclusion, although this study confirms the efficacy of the apex of Sedillot's triangle for IJV cannulation where bedside ultrasound imaging is unavailable, it also highlights the risks of this procedure in view of the variability of the relationship of the SCM heads to the location of the IJV on both sides.

Ethical approval was not required for this study as consent was obtained from all donors prior to decease for anatomical education, training, and research.

P27 Aortic arches in Ireland: a combined cadaveric and radiological study

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The aim of this study was to compare aortic arch (AA) branching patterns in Ireland using cadaveric dissection and radiological imaging.

Over a 2-year period, cadaveric dissection of all donors at Trinity College, Dublin (TCD) was performed; AAs and their branches were dissected, photographed, and recorded. Following this, AA branching pattern of all patients undergoing CT angiography at University Hospital Galway (UHG) over a 1-year period were retrospectively reviewed. Twenty-four cadavers at TCD were included: 19 donors (79%) had a 'normal' branching pattern. The bovine variant (two-branched AA) was observed in three cadavers (13%). Two cadavers (8%) had a four-branched pattern whereby the left vertebral artery (VA) arose directly from the AA.

In all, 383 live patients undergoing CT angiography of the thorax were included for comparison. Of these, 305 patients (79.6%) had a 'normal' AA; 56 patients (14.6%) had a bovine variant; 17 patients (4.4%) had a four-branched variant consisting of a left VA arising directly from the AA; two patients (0.5%) had a three-branched AA consisting of bovine variant in combination with left VA. Two patients (0.5%) had an Aberrant right subclavian artery arising as a fourth branch of the AA. One patient (0.2%) had a thyroid artery arising directly from the AA.

Awareness of AA branching patterns is important for anatomists, radiologists, and surgeons, particularly those performing endovascular procedures. Patients with variant branching patterns are at higher risk of stroke and thoracic aortic aneurysm (TAA). In addition, pre-operative awareness of AA variation allows for better pre-operative planning in TAA surgery.

Ethical approval for cadaveric dissection was not required as all donors had previously consented for their bodies to be used for the purposes of research and teaching. Ethical approval for the radiological component of the study was granted by the research ethics committee at University Hospital Galway (UHG).

P28 Variations of the cephalic vein: human cadaveric study

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Identification of the cephalic vein in the deltopectoral groove is of anatomical and clinical importance in emergency cardiac catheterisation. The aim of this study was to investigate cephalic vein variations in the deltopectoral groove. The formaldehyde-fixed bodies were obtained from the Anatomy Division, University of Edinburgh, which is regulated by the Human Tissue (Scotland) Act 2006. The bilateral shoulders of five cadavers (three males, two females: average age of 68.8 years) were dissected to determine the course, tributaries, and termination of the cephalic vein. The cephalic vein was observed in 90% ($n = 9$) of specimens, but in 10% ($n = 1$) the right vein was absent. In 90% of the specimens, the cephalic vein was seen to follow the classical anatomical course and drained into the axillary vein. Medical procedures including implantable cardioverter defibrillator (ICD) lead insertion or central venous catheterisation of the cephalic vein are highly invasive procedures; therefore, consideration of any cephalic vein variations is essential to prevent injury to the surrounding anatomical structures. Although this is an important finding, the current study was limited by the small number of cadavers; therefore, further investigation is recommended to evaluate further variations and their incidence in a larger cohort.

P29 The 'textbook human aorta': a *rara avis*?

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The widespread adoption of endovascular aortic aneurysm repair in recent years has necessitated an accurate understanding of the infraceliac aortic anatomy. Anatomical textbooks typically depict a straight abdominal aorta with the right and left renal arteries (RRA + LRA) arising symmetrically at a 90° angle, gonadal arteries arising immediately below the renal arteries, and the aorta bifurcating into the common iliac arteries at a 60–90° angle. This study aimed to describe the

infracoeliac abdominal aorta and to determine the accuracy of this representation.

The retroperitoneum was dissected and the branches of the abdominal aorta were identified in 35 embalmed adult cadavers in the Human Dissection Room at the University of Cambridge. The location, angle, and length of each branch were measured, with the mean of three measurements being used in data analysis. Results differed from the typically depicted aorta in a number of areas. The left renal artery generally arose more inferiorly than the right as measured from the origin of the superior mesenteric artery (SMA to RRA 0.9 ± 0.7 cm, SMA to LRA 1.3 ± 0.7 cm). Both renal arteries were typically angled caudally (RRA $74 \pm 17^\circ$, LRA $72 \pm 17^\circ$), with marked angulation ($\leq 40^\circ$) in three and cephalad angulation in two cases. Accessory renal arteries, considered uncommon, were nonetheless found in over 30% (11/35), and bilaterally in three subjects. Interestingly, the gonadal arteries did not arise from the abdominal aorta in 28/35 cases (80%). The angle between the common iliac arteries was most variable, with an average angle of $42 \pm 20^\circ$. This study demonstrates that the infraceliac abdominal aorta differs from its 'textbook' description in several features: the location and angle of the renal arteries; the prevalence of accessory renal and gonadal arteries; and the angle of the aortic bifurcation. This considerable variation must be taken into account in pre-operative planning of endovascular aneurysm repair.

Ethical approval: No ethical approval was required for the publication of this abstract.

P30 Variation of the radial nerve in human cadavers

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The radial nerve (RN) provides motor and sensory innervation to the posterior compartments of the arm and forearm. Radial nerve lesions can cause weakness or paralysis of the arm and forearm extensors as well as sensory deficits. The aim of this study was to analyse RN variation. The cadaveric bodies were donated to the University of Edinburgh Anatomy Department, regulated by the Human Tissue (Scotland) Act 2006. A total of five Genelyn-fixed bodies, three males and two females (mean age of 66.8), were studied. A full dissection of the axilla, and both the anterior and posterior compartments of the arm and forearm was performed. A full exposure and account of RN was completed. Of 10 RNs, 10% ($n = 1$) were found to exhibit variation. In one male cadaver, the right RN divided into four branches immediately after arising from the posterior cord. The first branch ran inferolaterally and pierced the medial head of triceps brachii before it gave off a communicating branch to the ulnar nerve. The remaining three branches passed posteriorly through the triangular interval with the profunda brachii artery. Once through, the second and third branches were observed to supply triceps brachii and extensor carpi radialis longus, respectively, whereas the fourth branch followed the classical course of the RN in the arm and forearm. Limitations of this study were the small sample size ($n = 10$) and unknown medical histories. In conclusion, peripheral nerve damage due to humeral head fracture has been extensively documented, with RN injury occurring in approximately 11% of cases.

Humeral fractures are often treated operatively and rare unilateral branching patterns may increase the risk of complications, such as entrapment and severance. Conversely, such variation may increase the potential for sparing of motor and sensory function upon damage to localised RN segments.

P31 Mapping the lateral cutaneous nerve of the forearm and its relation to the superficial radial nerve in human cadavers

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The lateral cutaneous nerve of the forearm (LCNF) is typically described as mediating sensory innervation from both dorsal and palmar surfaces of the radial forearm proximal to the wrist. However, anecdotal evidence suggests it may also mediate sensation from the skin of the anatomical snuffbox and first dorsal web space, classically attributed to the superficial radial nerve (SRN).

This study aims to map the course of the LCNF, the site where it pierces deep fascia, and its relation to the SRN in the distal forearm and dorsum of the hand.

Superficial dissection of 25 cadaveric forearms was performed with 2.5× magnification loupes, with careful mapping of both LCNF and SRN as far as the MCP joints. Our results showed that the LCNF emerged at a distance of 7.14 cm (SD 2.36 cm) from the lateral epicondyle, with up to five dorsal branches, although the majority [17/25 (68%)] gave only one. It was observed that 7/25 (0.28%) did have branches to the skin over the anatomical snuffbox and 5/25 (20%) to the first dorsal webspace. In addition, 6/25 (24%) showed a connection between the two nerves, at an average distance of 22.37 cm (SD 2.38 cm) from the lateral epicondyle.

These data highlight the variation that exists in the branching pattern of the LCNF and its relation to the SRN, as well as confirming that branches of the LCNF may supply areas previously only ascribed to the SRN. Surgeons operating in the cubital fossa should be aware of this possibility, as injury to the LCNF may lead to sensory loss in the hand. More importantly with regard to clinical diagnosis, these findings also bring into question the belief that the anatomical snuffbox and first dorsal webspace are autonomous zones for testing the integrity of the radial nerve.

Many thanks to the donors whose generosity enabled this project. Ethical approval was not required for this project as all our donors had consented to the use of their bodies for anatomical education, training, and research.

P32 Multiple tendons of abductor pollicis longus: a human cadaveric study

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De Quervain stenosing tenosynovitis is one of the most common causes of radial-sided wrist pain. Pathological inflammation of the tendons of abductor pollicis longus, extensor pollicis brevis, and extensor pollicis longus can produce symptoms of pain, weakness, and muscular spasms. Knowledge of the anatomical variations presented by these muscles can be of clinical importance when considering the assessment and management of any diseased or traumatised hands for tendon repair or allograft.

The Genelyn-fixed bodies were obtained from the Anatomy Division, University of Edinburgh, which is regulated by the Human Tissue (Scotland) Act 2006. During routine dissection of three bodies (one male, two females: average age of 74 years) for the MSc Human Anatomy postgraduate course 2016–2017, one right abductor pollicis longus was observed to have six tendons, inserting into the lateral and anterolateral sides of the base of the 1st metacarpal, thenar fascia, opponens pollicis, abductor pollicis brevis, and trapezium.

Surgical decompression of the osseo-fibrous canal involving the abductor pollicis longus, extensor pollicis brevis and extensor pollicis longus tendons is the gold standard surgical treatment for De Quervain stenosing tenosynovitis. However, decompression of this canal may not relieve the symptoms if any of the accessory tendons are unidentified and remain compressed on to the fibrous canal. Despite the fact that this is an important finding, the current study was limited by the small sample size. Further study is recommended to evaluate further possible anatomical variations of abductor pollicis longus in a larger cohort.

P33 Variation of levator scapulae in human cadavers

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Levator scapulae (LS) is linked to cervical and shoulder pain. LS variations may not only cause pain radiating from the neck to the scapula, but also could lead to reduced mobility of cervical vertebral joints. Despite all, variations of LS have seldom been reported; therefore, the aim of this study was to evaluate LS variations.

The cadaveric bodies were obtained from Anatomy, University of Edinburgh, regulated by the Human Tissue (Scotland) Act 2006.

Five adult formaldehyde-fixed bodies (three males, two females) were studied, with a mean age of 66.8 years. All of the skin, superficial, and deep fascia of the back, as well as trapezius were dissected and reflected. A full exposure and record of LS have been accomplished.

Variation in LS is found in 20%, both were observed in one male. On the right side, the LS is observed to be multi-banded arising from the mastoid process and C2 transverse process, and inserting into the scapula superior angle, whereas the third band arises from C3 transverse process and inserts into the second rib close to its angle. On the left side, two bands originate from the mastoid process and insert into C7 spinous process and scapula superior angle, respectively, whereas the third band arises from C1 transverse process and inserts into both scapula superior angle and subscapularis.

Limitations are small sample size ($n = 5$) and unknown medical histories.

Variations of LS were observed in 20%. The presence of multi-banded LS is not only associated with the surgical translocation and reconstruction but is also considered to be a frequent contributor to cervical myofascial pain, often as a result of improper posture; therefore, surgeons, physiotherapists, and other medical professionals should not exclude that such variation could be the underlying aetiology.

P34 Anatomical measurements of the human anterior and posterior menisofemoral ligaments

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The detailed anatomy of the menisofemoral ligaments has not often been described. A study was therefore carried out on Thiel-embalmed knees to provide a detailed anatomical analysis of the anterior (aMFL) and posterior menisofemoral ligaments (pMFL) of the human knee joint. Measurements using digital callipers were obtained from the ligaments of 21 males and 19 females with an age range of 47–100 years. Means \pm standard deviation (SD) of aMFL length, aMFL femoral width, aMFL mid distance width, and aMFL meniscal width were 28.1 \pm 2.9 mm, 6.4 \pm 1.7 mm, 4.1 \pm 1.1 mm, and 4.0 \pm 1.2 mm, respectively. Means \pm SD of pMFL length, pMFL femoral width, pMFL mid distance width, and pMFL meniscal width were 29.1 \pm 3.7 mm, 5.8 \pm 1.5 mm, 4.7 \pm 4.6 mm, and 4.2 \pm 1.2 mm. The means \pm SD of femoral footprint of aMFL length and femoral footprint of aMFL width were 5.1 \pm 3.8 mm and 7.9 \pm 2.5 mm, respectively, and the femoral footprint of pMFL length and femoral footprint of pMFL width were 5.1 \pm 1.5 mm and 6.7 \pm 2.2 mm, respectively. A significant difference in aMFL femoral width ($P \leq 0.001$), pMFL mid distance width ($P \leq 0.002$), and femoral footprint of pMFL width ($P \leq 0.02$) was observed between males and females, despite them having almost identical measurements of the aMFL mid distance width, aMFL meniscal width, pMFL length, pMFL femoral width, pMFL meniscal width, femoral footprint aMFL length, femoral footprint aMFL width, and femoral footprint pMFL length. There was also a significant difference ($P \leq 0.04$) in the femoral footprint of pMFL length between the right and left knees. This study has given insight into the detailed morphology of these ligaments, whose function has not yet been clearly defined.

No ethical approval additional to body donation paperwork was required.

P36 Are wall thickness and fat cover of the human colon factors in iatrogenic perforation?

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Colonoscopy is performed frequently as part of screening for colorectal cancer, and carries a small but serious risk of perforation with peritonitis.

We wondered whether perforation could be related to 'danger areas' in the wall of the colon. We reasoned that where the wall was thin, the chance of perforation would be higher, and where the fat cover was less, a perforation would be more likely to lead to peritonitis.

To test this hypothesis we examined tissue from three embalmed cadavers from the Donor Programme of the University of Glasgow, donated under the Human Tissue (Scotland) Act 2006 for the purpose of anatomical examination. None showed signs of intestinal disease and each had consent for retention and electronic imaging of parts for education, training, and research purposes. In each case, cross-sections were taken from the middle region of the ascending, transverse, descending, and sigmoid colon, and photographed. The photographs were analysed on AXIOVISION computer software and the minimum wall thickness and percentage fat cover for each segment was measured.

We found that wall thickness and fat cover varied in each segment, and between different segments. Three of eight areas with a wall thinner than 1.60 mm and two of eight areas with fat cover of less than 67% were in the transverse colon.

In practice, perforation is most common in the rectum and sigmoid colon, and this suggests that curvature, mobility, and frequency of examination, and possibly intrinsic disease, may be more important factors in perforation than variation in structure of the wall.

The submucosa seemed thicker where the wall was thin, like a 'safety net', but this was not confirmed by measurement.

Cadavers donated under the Human Tissue (Scotland) Act 2006 for the purpose of anatomical examination. Each had consent for retention and electronic imaging of parts for education, training, and research purposes. Given that this investigation is an 'anatomical examination' it fully fulfils the purpose of the donation, and therefore no further ethical approval is required.

P38 Advancing management of trigeminal-mediated headshaking in horses: collaboration between clinician and anatomist: preliminary study to identify the sphenopalatine ganglion and landmarks for percutaneous access for neuromodulatory treatment

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Trigeminal-mediated headshaking in horses is a neuropathic facial pain syndrome with clinical similarities to neuropathic head and face pain syndromes in people. No consistently safe and effective treatment currently exists, with many cases ending in euthanasia. Neuromodulation using percutaneous electrical nerve stimulation (EquiPENS™) of the infraorbital nerve is currently the safest treatment, but results in long-term benefit to only 25% of horses. Targeting the sphenopalatine ganglion

(SPG), which conveys sensory fibres from the maxillary division of the trigeminal nerve (V2), and parasympathetic and sympathetic fibres to the mucosa and glands of the nasal cavity, could result in a more effective treatment for neuropathic pain in horses, with translational potential, if landmarks for percutaneous access can be established. The location of the SPG was determined in a freeze-thawed cadaver obtained from an abattoir. The masseter and medial pterygoid muscles were transected to expose the pterygopalatine fossa, while the zygomatic arch was left intact. The masseter was removed from the facial crest to reveal the deep facial vein. This was traced caudally to enable identification of the maxillary artery. Immediately deep to this vessel lay V2, with the pterygopalatine nerve lying deep to that. The SPG was identified as a 1-cm-long structure lying between the palatine bone and the pterygopalatine nerve. It was removed and fixed in formalin for histological confirmation. Once located, landmarks to locate the SPG percutaneously and the angle at which a needle must be inserted, were determined. This preliminary study confirmed the location of the SPG and the anatomical landmarks which can be used to locate it percutaneously.

University of Bristol Ethics Committee VIN 13/039.

P39 Sexual dimorphism in adult human Caucasian and Asian dry skulls

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Sex and population determination using craniometric measurements from the adult human skull is commonly performed by anthropologists worldwide. It forms part of a biological profile to assist in human identification. Currently, there is a lack of such data for males and females from a British and Irish, Malay and Singapore or Indian population. The aim of this study is to investigate statistically significant craniometric differences between sexes of adult human skulls from British and Irish, Malay and Singapore, and Indian populations. To investigate the statistically significant differences between these three populations, a sample of 282 adult human skulls from the 18th and 19th century were borrowed from the University of Edinburgh anatomical collection. A total of 10 craniometric distances were measured in each skull according to standard osteometric techniques and the data were analysed using SPSS version 23 software. Results indicate that there is a statistically significant difference between sexes across all three populations, with male skulls having larger craniometric measurements than female skulls. There were also statistically significant differences between populations, with the British and Irish population having larger craniometric measurements than both the Malay and Singapore, and Indian populations. Using discriminant function analysis for all the skulls measured provided discriminant accuracy of 48.3% for British and Irish males, 68.2% for British and Irish females, 42.5% for Malay and Singapore males, 64.7% for Malay and Singapore females, 37.5% for Indian males, and 62.5% for Indian females with an overall success rate of 42.5%. Statistically significant sexual dimorphism was reported within all three populations as well as between these populations. Craniometric measurements of the

adult human skull provide a utility in identifying sex and population.

Ethical approval: All skulls utilized in this study are from the University of Edinburgh anatomy department, regulated by the Anatomy Act 1984.

P40 The correlation between lip width and the distance between the teeth among adult human subjects

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Accurate reconstruction of the lip area is an important part of forensic facial reconstruction. Although several facial landmarks have been used to accomplish this purpose utilising photographs or CT scans, certainty regarding the morphology and the dimensions has not yet been achieved. This study uses tooth landmarks in the maxillary jaw to correlate with the width of the lips and aims to evaluate the accuracy of the common methods used to estimate lip width from the dentition and to derive new standards that could be used for lip estimation.

A total of 111 multinational participants (76 female, 35 male, mean age 27.62 years) were recruited for this study. Vernier callipers were used to measure the distance between the maxillary central incisor, lateral incisor, canines, and the first premolar as well as the distance between the corners of the lips. Data were statistically analysed using SPSS software, the Pearson correlation, mean, and standard deviation. The preliminary results of this study are that the distances between the teeth on either side of the maxillary canines (lateral incisors and first premolars) both exhibit a strong statistical relationship with mouth width ($r = 328^{**}$ and 408^{**}), respectively. There was no significant sexual dimorphism in the measurements. These results could be useful for more accurate estimations of mouth width from teeth landmarks during forensic facial reconstruction.

P41 Quantification and preference of facial asymmetry of the sub-Saharan African 3D facial models

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A substantial body of literature has reported on facial symmetry and asymmetry and their role in human mate choice. However, major gaps persist, with nearly all data originating from the WEIRD (Western, Educated, Industrialized, Rich, and Developed) populations, and results remaining largely equivocal when compared across studies. This study aimed at quantifying facial asymmetry from the 3D faces of the Hausa of northern Nigeria and also at determining their perceptions and judgements of standardised facial images with different levels of asymmetry using rating. Data were analysed using R-studio software and results indicated that males were 12% (0.35 mm) and 15% (0.23 mm) more asymmetric in the face and eye, respectively,

than females (Face 0.3 mm, Eye 0.20 mm). Additionally, individuals with lower levels of facial asymmetry (near facial symmetry) were perceived as more attractive, more suitable as marriage partners, and more caring, whereas individuals with higher levels of facial asymmetry were perceived as more aggressive. The study conclusively asserts that all faces are asymmetric, including the most beautiful ones, and the preference for less asymmetric faces was dependent not just on a single facial trait but rather on multiple facial traits; thus, the study supports that physical attractiveness is not just an arbitrary social construct but at least in part a cue to general health and possibly related to environmental context.

Ethical approval to scan the faces of the subjects were given by the University College London and Federal Ministry of Health Nigeria.

P42 Constructive regression in the juvenile human ischium: a quantitative analysis

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A potential period of resorptive skeletal development has been qualitatively identified during infancy in the human juvenile ischium. Termed 'constructive regression', it is hypothesised that this period is indicative of the release of calcium to facilitate rapid early post-natal growth following a period of perinatal accumulation.

High resolution three-dimensional data of 28 ischia (birth to 3 years) was obtained via microcomputed tomography. These were grouped into Phase 1 (perinatal, $n = 20$), Phase 2 (0.5–2 years; $n = 5$), and Phase 3 (1.5–3 years, $n = 3$). SkyScan CTAnalyser was used to calculate bone volume fraction (BTV), trabecular number (Tb.N), and trabecular thickness (Tb.Th) across 16 volumes of interest. Analysis of variance and multiple pairwise comparisons were used to test for significant differences.

Mean bone volume fraction was found to fall significantly between Phase 1 (neonatal) and Phase 2 (5–18 months), from 34.2% to only 22.5% in Phase 2. Mean trabecular number decreased significantly in Phases 1, 2, and 3, from 2.9 mm^{-1} in Phase 1 to 0.97 mm^{-1} in Phase 3. However, mean trabecular thickness continued to increase progressively through Phase 1, 2, and 3, from 126.7 to 180.1 μm .

These quantitative results suggest that, although characterised by an overall loss of bone mass, 'constructive regression' is a progressive stage in skeletal development. Although BV/TV was found to decrease significantly, the concurrent decrease in Tb.N and increase in Tb.Th is consistent with trabecular 'sculpting' in the adult in response to mechanical loading. Regional changes were most pronounced in areas which expressed the highest BV/TV in Phase 1, which also suggests that resorptive changes occur primarily where an excess of bone tissue may be present. The period of constructive regression therefore may represent a 'switch' between genetically controlled bone accrual *in utero* and biomechanically driven post-natal maturation.

Ethical approval: Specific ethical approval was not required for this study due to the historical/anatomical nature of the collection studied.

P43 Morphological aspects of syncytiotrophoblast nuclear organisation patterns in the human placenta

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Pre-eclampsia and intrauterine growth restriction are two of the most important pregnancy complications worldwide and have been associated with abnormalities in placental trophoblast turnover. Histological evidence shows that syncytiotrophoblast nuclei form specific spatial arrangements and patterns that influence the pathological appearance of some diseased placentas. It is not known whether links exist between these nuclear organisational patterns and how trophoblast cell turnover is organised and controlled.

SUN-KASH proteins are nuclear-envelope bridges responsible for the physical links between nuclei and the cytoskeleton and are required for nuclear organisation in a variety of cells. They are known to play a role in cell turnover and have been implicated in human diseases. These include the laminopathies, some of which affect another syncytium, human skeletal muscle. We propose that the SUN-KASH proteins, through their cytoskeletal interactions, are involved in syncytiotrophoblast nuclear organisation and regulation of their turnover. To examine this hypothesis we established a novel placental sampling method, fine needle aspiration, and compared it with the usual tissue block processing. Using immunohistochemistry to detect the SUN-KASH proteins and confocal laser scanning microscopy (CLSM), we show that this new method allows faster analysis of large numbers of placental villi, reduces the need to scan large areas of tissue, and can be rendered in three dimensions using CLSM. Furthermore, we show that the SUN proteins SUN1 and SUN2 as well as the KASH proteins SYNE1 and SYNE2 are expressed at the nuclear envelope of the trophoblastic syncytium.

This study was approved by the Clinical Research Ethics Committee of the Cork Teaching Hospitals [log ECM 4 (p) 06/11/12].

P44 Insights into the ketone diet and neuronal cell function: examining the effects of ketone supplementation on the neuronal-like cell line SH-SY5Y

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Ketogenic diets (KD) (low in carbohydrates and high in fats) have become increasingly popular in recent years due to their effectiveness for weight loss and in the treatment of neurological disorders such as epilepsy. Although these diets represent a promising alternative to medication for those suffering from epilepsy, there is limited information about how

KD affects normal brain functioning. Furthermore, there is very little research on how sustaining the KD during pregnancy affects the developing brain. When glucose levels are low or absent due to a lack of carbohydrate consumption, ketone bodies are the predominant energy source produced when fat is metabolised. Beta-hydroxybutyrate (β HB), a ketone body, is present at relatively high levels after fasting and plays roles in cellular respiration when glucose is absent. Studies have addressed how replacement of glucose with ketone bodies affects glutamate transmission in adult neurons and its effects on neuronal firing via potassium and calcium channels. Moreover, recent studies have begun to show how the KD during pregnancy affects the health of both pregnant mice and the developing fetal brain. In particular, brain volumes differ significantly after neural tube closure and specific brain regions vary in size post-natally, when compared with standard-diet fed controls. This indicates that alterations in brain architecture may stem from neuroepithelial cell proliferation and differentiation. SHSY-5Y cells are an immortalised cell line used as a model of neuronal cell function and differentiation. In this study, we used SHSY-5Y cells to gain an increased understanding of the effects of β HB on the growth and function of dividing neurons. We analysed the morphology and proliferation rates of SHSY-5Y cells supplemented with 1 and 5 mM β HB and compared them with glucose-depleted and regular-feeding medium. The effects of ketone supplementation were examined morphologically over time and immunocytochemically analysed using GAP43, which is found on growing axons, NeuN, a post-mitotic neuronal marker and β III-Tubulin, a cytoskeletal marker. Early investigations show decreased proliferation rates and cellular structural alterations in β HB-treated groups over time, suggestive of cell cycle abnormalities and alternations in differentiation capacities. Ongoing research is further defining the effects of ketone supplementation on neuronal proliferation and lineage. Ethical approval was not required to conduct this study.

P45 Modelling the development of human tissues *in vitro* using a combination of advanced cell technologies and mammalian stem cells

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tissue development. However, the assay is limited due to a high level of variability, with examples including differences in initial cell seeding number, graft site location, and assay length. These are known to influence the differentiation trajectory of HPSCs, reducing comparability between assays and influencing assay results. Therefore there is need for a consistent and reproducible method to assess differentiation capacity, which can permit time-dependent studies and allow for complex structure formation. We have developed a novel three-dimensional *in vitro* model which permits the extension of embryoid body viability through reducing diffusion distances in these structures, enabling longer *in vitro* culture and the formation of complex tissue structures. Model optimisation involved using pluripotent stem cell lines to highlight the ability to culture the tissues for up to 35 days. The physiological relevance of the model has been further enhanced through the introduction of a novel perfusion system and co-culture with primary fibroblasts to simulate subcutaneous grafting of cells. These enhancements create a model which more closely mimics the physiology of the teratoma microenvironment, resulting in more complex cell differentiation and tissue structure formation. It is anticipated that this model will provide a novel, standardised animal-free *in vitro* alternative to the current teratoma assay and provide an approach to investigate the early stages of tissue development. All teratoma samples used were from a previous study conducted at the institution, which was given permission from the University, and was conducted in accordance with UK Home Office Guidelines.

No other ethical approval was required for this study.

The teratoma assay has long been recognised as a 'gold standard' method to evaluate the pluripotency of human pluripotent stem cells (HPSCs), with further applications in the study of human