Sir Jules Thorn Charitable Trust (medically related donations programme)
Intra-Operative MRI Suite, Southampton Children's Hospital

Evidence of need

World class paediatric neurosurgeons rely on MRI scans taken beforehand to guide them during an operation on a child or young person. Time is of the essence in brain surgery and precision is paramount to avoid irreparable damage which could affect them for the rest of their life. However, MRI images quickly become inaccurate because the brain shifts during surgery and some affected tissue can be undetectable to the naked eye. It is only in the days after surgery, when another scan is taken, that surgeons can see if it was a success. Families face an unbearable wait while their child stays sedated in the Paediatric Intensive Care Unit.

Survival in children with brain tumours is almost entirely dependent on whether it is completely removed, if some is left behind survival rates can drop as low as 40%. Of all cases, 80% are emergencies. Success within the first 24-48 hours is crucial, yet nearly half of all children seen by the department need multiple operations. They spend an average four days sedated in the Paediatric Intensive Care Unit after or between operations, sometimes up to ten days, bringing additional risk of medical complications. Families anxiously wait to know the outcome of surgery and whether their child has any degree of brain damage.

Our solution

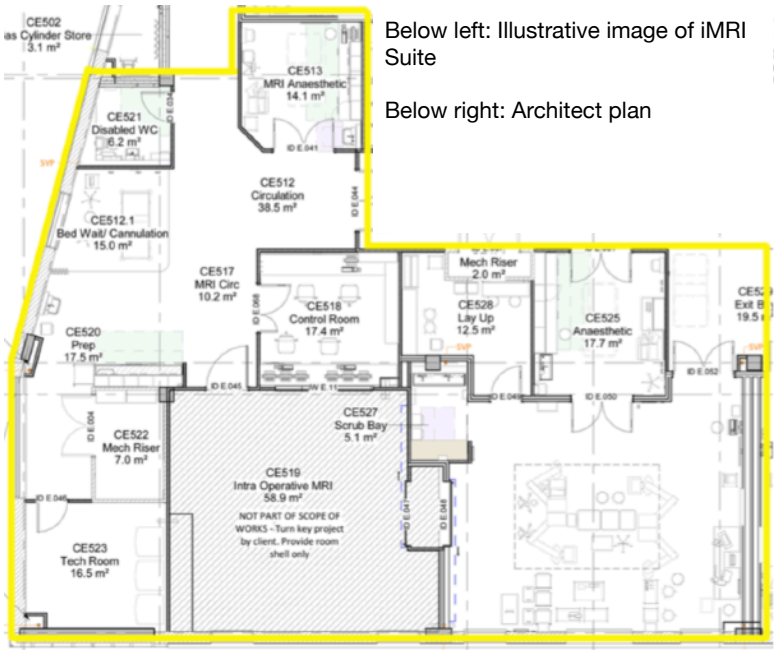
Thanks to charitable support a handful of UK children's hospitals have iMRI - an integrated operating theatre and MRI scanner room which allows surgeons to scan the brain any number of times whilst the child is still on the operating table. Near real-time images give a far greater chance of success within just one operation and enabling neurosurgeons to safely push the boundary of what is currently possible. We shared more information in our short film here.

"Where it is difficult to tell between healthy tissue and a tumour, we always err on the side of caution. iMRI is effectively a sat nav that gives children the best chance ever to have a complete removal of a tumour. We can scan the patient whilst the operation is underway, so we can make sure a tumour is completely removed and surgery is safer. The most advanced neuro-navigation system in the UK will guide us with absolute precision. This will totally transform brain surgery." Aabir Chakraborty, Lead Neurosurgeon

We aim to create this cutting edge facility at Southampton Children's Hospital to bring this advanced technology closer to home for children in central southern England. University Hospital Southampton have committed £4.8m towards the £6.9m project as part of a vertical extension to the hospital. Our campaign aims to raise £2.1m to fund the most transformational elements - the scanner itself and other specialist equipment/software.

Below left: Illustrative image of iMRI Suite

Below right: Architect plan



Covid-19: accelerated urgency

The iMRI Suite sits within a major extension to the hospital which houses new operating theatres and intensive care facilities. The build of the suite is complete and the theatre will be operational by September 2021. The rooms that transform it into an iMRI will be completed in Phase Two, only when our £2.1m target is reached. Covid-19 has dramatically accelerated the urgency for this project:

"Treatment of children with brain tumours has been devastatingly impacted by Covid-19. Some children are presenting much later in their illness and, as a result, in a far worse condition and survival rates are inevitably affected. This campaign is even more important now. The sooner the target is reached, the sooner more lives can be changed for the better." Aabir Chakraborty, Lead Neurosurgeon (right)

As the impact of pandemic is likely to continue in the medium term, the quantifiable extent of this impact on survival rates is yet to be fully understood.

Who the iMRI will benefit

Southampton's paediatric neurosurgery department primarily treats children and young people from nine counties in central southern England: Hampshire, Isle of Wight, Channel Islands, Sussex, Berkshire, Surrey, Wiltshire, Dorset. However, the hospital's neurosurgeons are world class and children from further afield in the UK are also referred for specialist treatment.

Every year, the department operates on c.225 children and young people. The average age is 6 years with 30% are under 2 years old, including 600g premature babies. The most common reasons for surgery is brain, pituitary and spine tumours or hydrocephalus (fluid on the brain). Other conditions include head trauma, brain haemorrhage, movement disorders, epilepsy and neuropsychiatric disorders.

"Keisha was diagnosed with a brain tumour when she was nine. She had many, many operations in Southampton Children's Hospital to try and remove all of the tumour. She dreaded the experience of having an MRI scan after each operation if she was conscious. She was terrified, she screamed so much.

We finally got the all-clear, but it came back. Now she was older, Keisha did her own research and found there was an Intra-Operative MRI in Alderhey Children's Hospital. She decided she'd rather travel six hours to Liverpool if it would give her the best chance. The photo is at her prom, just after her last operation, aged 17. Soon after, she lost her fight. We know she would have done anything for this appeal to bring an iMRI to Southampton." Zoe, Keisha's Mum

Transformational impact

Compelling outcomes from iMRI are reported in other hospitals. In one, repeat operations reduced to zero. In another, 70% of operations were extended only due to additional information provided by iMRI, avoiding multiple operations. Nine ways in which your gift will help:

1. Surgeons will have confidence in push the boundaries of surgery beyond what is currently possible, enabling them to remove more tumour/affected tissue and leading to better patient outcomes
2. Number of operations endured will reduce to one for most children
3. The average 4 days a child stays sedated in Paediatric Intensive Care will reduce almost entirely
4. Families get the answers they need quicker, reducing unimaginable stress and anxiety
5. Risks of severe complications from multiple/prolonged general anaesthesia or sedation will reduce
6. Surgery becomes safer with live, detailed imaging to guide surgeons
7. Children return home quicker as length of stay in hospital reduces
8. Increased no. of children each year: increased capacity enabling referrals within the wider area
9. Significant additional capacity created within the Paediatric Intensive Care Unit and MRI routine/ diagnostic scanning for both adults and children

Efficiency: wider benefits

When the scanner is not in use intra-operatively for paediatric neurosurgery, to maximise efficiency it will provide scanning capacity for other paediatric and adult patients. This will make a significant difference to patients treated within the wider hospital by providing more rapid/appropriate access to MRI scanning.

- Paediatric diagnostic scanning will be moved to the child-friendly environment of the new iMRI. All adult inpatient scanning will move to the iMRI where there will be more privacy and dignity than in the busy radiology department which also manages outpatients appointment.
- Interventional MRI procedures (e.g. ablation work - freezing/heating cancer tumours to destroy them) would also be moved, providing these patients with easy access to the post-operative area as they recover, even though they are not a theatre case per sae. This is safer because such procedures, under general anaesthetic, heavy sedation and strong pain relief, come with a level of risk.
- This could provide as much as 30 hours of new scanning capacity to reduce waiting times for patients, whether for routine or cancer diagnostics. This equates to c.2,850 patients per year and would mean these patients can get earlier diagnosis and, crucially, earlier treatment. MRI capacity is the biggest constraint in terms of diagnostic waiting times, both locally and nationally, and growth in demand for MRI imaging is increasing at a rate of 14% annually.
- Anticipated reduction in days required in the Paediatric Intensive Care Unit for children undergoing surgery will free up bed space for other critically ill children.

Project budget

The NHS Trust have committed £4.8m towards the £6.9m iMRI Suite. Our £2.1m appeal will fund some of the most specialist elements and make it possible to bring this advanced technology closer to home for hundreds of children each year. Our charity will fund the purchase of the equipment/software below:

Item	Cost £	Secured £
1.5T MRI scanner (Feb 2021: Siemens agreed additional £100k discount in lieu of a donation - this is presented as corporate pledge in income figures below)	950,000	
Faraday cage in walls/floor/ceiling to shield from radio frequency	300,000	
Advanced neuro software to enable specialist intra-operative scanning	300,000	
*Theatre table & transfer/docking system to move the child from theatre to scanner	120,000	
*Cardiac monitoring system	62,000	
*Contrast injector	35,000	
*Wheel chairs x 3	4,400	
*Other equipment TBC	28,600	
*LED art panels on walls/ceiling of scanner room: reduced stress for conscious patients	6,700	6,700
Distraction kit in “bed wait”: calm space for families as child is prepared for surgery	6,900	6,900
Fundraising costs / 4 years	300,000	100,000
TOTAL (*Specialist equipment that is MRI compatible)	2,113,600	

Cash flow forecast, fundraising and reserves

The original cashflow forecast was developed on the basis of completion in December 2023. However, it has been updated with a more ambitious timeframe given the project’s increased urgency.

To date, including pledges, we have secured £567k towards the £2.1m target. When we reach the £1m milestone (£433k variance), we can reignite positive conversations with two philanthropists who may contribute a combined £750k. A gift from the Sir Jules Thorn Charitable Trust towards one of the higher level funding opportunities presented later in this document could add more immediate leverage and be instrumental in making the iMRI Suite operational in 2022.

As a large capital appeal in its early stages, fundraising has been significantly impacted during 2020 and 2021, with funders prioritising COVID-19 response and most public fundraising paused. Postponed events are now planned for 2022 to maximise potential to open the iMRI during next year: 2x “Odd Ball” dinners (£120k), Christmas Concert (£70k), Gobi Desert 500km hand cycle with quadruple amputee Alex Lewis (£50k), “Hares of Hampshire” sculpture trail (£200k), Pig2Pig bike ride with Pig Hotels (target TBC).

Donors include Barker-Mill Foundation (£100k towards fundraising costs to increase impact of every gift), Siemens (£100k), Michael Bishop Foundation (£50k), Greendale Foundation (£20k), Acorns2Trees (£25k), Geoff and Fiona Squire Foundation (£25k), Hampshire and Isle of Wight Community Foundation (£9k), Hospital Saturday Fund (£5k) and Bernard Sunley Charitable Foundation (£5k).

The Murray Parish Trust reserves are held to meet the small operational/fundraising costs of our charity (6 months/currently £41k). Excess funds are granted at each project milestone, when required. Reserves levels are not anticipated to affect project plans, with delivery of the work planned to progress only when actual/pledged income reaches or nears target. During the pandemic, our trustees monitored cashflow carefully, reducing the hours of our small team to reduce costs. Return on investment reduced to a lower level than expected and reserves have grown slower than planned.

Cashflow forecast	Income to date £	2021 Q4 £	2022 Q1 £	2022 Q2 £	2022 Q3 £	2022 Q4 £	TOTAL £
Philanthropy	10,000	3,000	5,000	5,000	7,500	500,000	530,500
Trusts & foundations	214,500	75,000	250,000	175,000	20,000	0	734,500
Corporate	66,500	2,500	5,000	20,000	10,000	120,000	224,000
Events	15,000	5,000	50,000	120,000	200,000	70,000	460,000
Community/individuals	84,000	5,000	10,000	15,000	10,000	12,500	136,500
Other (incl. gift aid)	15,500	2,500	2,500	2,500	2,500	2,600	28,100
Total income	**405,500**	**93,000**	**322,500**	**337,500**	**250,000**	**705,100**	**2,113,600**
Appeal costs	**182,750**	**21,250**	**25,000**	**26,250**	**24,750**	**20,000**	**300,000**
Variance	**222,750**	**71,750**	**297,500**	**311,250**	**225,250**	**685,100**	**1,813,600**

Sustainability

The build of the shell of the iMRI Suite is complete and the operating theatre is being fitted out as part of a wider project; it will soon be operational as a standard theatre. The rooms that turn the area into an iMRI Suite will be completed only when we have reached our £2.1m target. University Hospital Southampton have committed funding for the rest of the project and any contingency required. No further charitable funding will be required to meet unexpected costs.

All running costs (incl. staffing, maintenance, upgrades to extend useful life) will be met by the NHS Trust. The useful life of the scanner is seven years, which can be extended by a further three years by upgrade of software. After this period, the hospital will conduct a full evaluation and create a business case for an NHS funded replacement. Healthcare needs/advances change over quite short periods of time. A summary of the seven year cashflow position is provided:

	£k Year 1	£k Year 2	£k Year 3	£k Year 4	£k Year 5	£k Year 6	£k Year 7	£k TOTAL
Total income	3,339	3,339	3,339	3,339	3,339	3,339	3,339	23,373
Total pay costs	1,951	1,951	1,951	1,951	1,951	1,951	1,951	13,657
Total non-pay costs	786	786	786	786	786	786	786	5,502
Total direct costs	2,737	2,737	2,737	2,737	2,737	2,737	2,737	19,159
Contribution	602	602	602	602	602	602	602	4,214

The facility will be included within the University Hospital Southampton's radiology department's managed equipment service programme. This programme provides an onsite team of specialist engineers who ensure all radiology equipment is run and maintained in such a way as to prevent damage or down time, both of which result in hours lost to patients and/or research. There is a ring-fenced allocation which is released annually as part of the NHS Trust's budget setting process.

Agreement for a financial uplift to this allocation, sufficient to cover iMRI servicing & maintenance for the lifetime of the machine was submitted as part of the business case considered by the Trust investment committee and executive group in 2019/20. The case also included detailed support staff costs and a schedule of the additional investment required to ensure that the iMRI suite functioned as intended. This case was approved for investment from the Trust subject to The Murray Parish Trust raising sufficient charitable funds to proceed.

Project milestones/timescales and risk

The iMRI Suite is part of a wider NHS funded project, a new vertical extension to develop the theatres and General Intensive Care Unit. The project plan summary is as follows:

Phase 1
New build of a three floor extension (D/E/F levels): work comprises the shell of eight theatres, MRI/related rooms adjoined to one theatre, plus build/fit out of intensive care unit.

Phase 2A
Jun 2020: Preliminary work
Sep 2020: Construction work starts
Jan 2021: Two existing cardiac theatres refurbishment
May 2021: Construction complete for four theatres/iMRI rooms on E level
Jun 2021: Fit out/commissioning of two theatres on E level, including theatre within iMRI Suite
Jul 2021: Completion of all work

UPDATE: The Expression of Interest application noted that £300k of charitable funds were required by May 2021 for the installation of the radio frequency cage. Decision was made to build to the stage of the shell within 2A so no major disruptive works will be required to install the cage retrospectively within phase 2C.

Phase 2B
Aug 2021: Fit out of remaining two theatres E level

UPDATE: Operationally, the ideal scenario was to install the iMRI (phase 2C) within phase 2B and delay the completion of all E level theatres/rooms until Sep 21. This would have incurred less total disruption, but plan was only possible with significantly accelerated fundraising success which was not realised.

Phase 2C
Completion of MRI related rooms to integrate with the theatre to create the iMRI Suite (8-10 week). Timing dependent on when The Murray Parish Trust's fundraising appeal is complete.

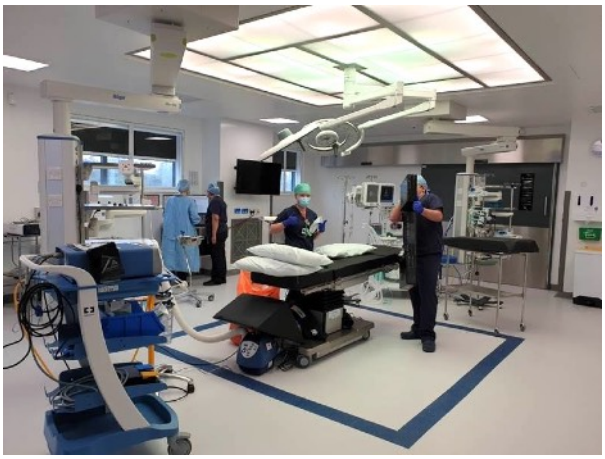
Phase 3 (2022)
Fit out of remaining four theatres F level

The plan reduces financial risk as work to complete the iMRI Suite only proceeds when the fundraising target is reached. Operational risks lie within the wider project for University Hospital Southampton, caused by the wait for fundraising success and the resultant stop/start plan. Due to its proximity, the paediatric neurosurgery theatre and surrounding footprint will need to close during work to complete the iMRI and there will be low-level noise disruption to the remaining three operating theatres.

Update: Paediatric neurosurgery has now moved from a shared theatre elsewhere in the hospital into the new theatre in July 2021.

The vacated space has been backfilled and so during iMRI installation, activity will need to temporarily move elsewhere reducing total operational capacity across a number of different surgical disciplines because all theatres will reduce activity to accommodate paediatric neurosurgery.

The completion of phase 2C is planned for Nov 22-Feb 23 (or Nov-Dec 23 at the latest). Scheduling work during winter, when elective surgery decreases and surgical beds are given over to medical admissions to support winter pressures, will reduce potential disruption, thus reduce impact on waiting times/patient care.

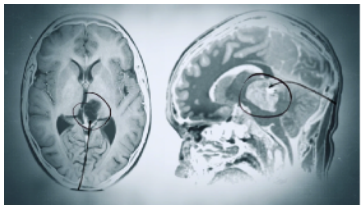


Above: The completed theatre, now in use. Doors to MRI room can be seen behind.

"Being told your child has a brain tumour must be one the on the hardest thing a parent has to hear. I'm involved in these conversations regularly. It doesn't get any easier. iMRI is proven to improve surgical outcomes and reduce need for multiple operations. This is such a positive step forward." Kate Bailey, Children's Neurosurgery Nurse Specialist

Matthew's story

Twelve year old Matthew had just started secondary school when he started getting headaches. Scans showed a rare tumour, the size of a plum, in centre of the brain. Without surgery, he had two months left.



"The pineal area is a challenging place to get to, deep within the brain. It's unknown territory, with many risk factors. Very few people perform this type of surgery. His case kept me awake at night. It was one of the most difficult tumours we deal with. It's an area packed with structures that perform critical functions like movement, sight, sensation and hearing"

Southampton Children's Hospital neurosurgeon's Aabir Chakraborty and Ryan Waters performed a delicate two-day operation through a narrow 1cm wide, 8cm long corridor to reach the tumour. The brain has many vital, often undetectable, arteries and veins - and tumours have numerous delicate blood vessels. If any are ruptured, a bleed can cause a stroke as that area quickly runs out of oxygen. The child may have irreparable brain damage or not survive the operation.

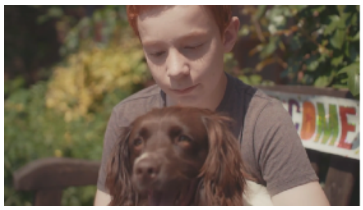
One of the tiny blood vessels that ran into Matthew's tumour ruptured. They worked hard to stem the serious bleed through the tiny corridor, not knowing if that blood vessel fed the tumour or if it passed through the tumour and a healthy part of the brain would be starved of oxygen. After 10 hours of surgery, Matthew was sedated in PICU overnight whilst they ordered an urgent MRI scan.

"It was a very long night. The scan showed the vessel fed the tumour and he hadn't had a severe stroke that could risk his life or severe disability. Yet. Tomorrow was another day…"

On day two, they continued to try and remove the tumour. It had woven itself into Matthew's brain and was hard to distinguish from healthy tissue. It was difficult to know if they had removed all of it.

"It's a balance of how far do I push surgery, versus what can he cope with. If we injured him permanently he might not go to school again, ride a bike, or see. It's a rock and a hard place. We got as much out as we felt comfortable with. As he recovered in PICU, I was anxious to see that he woke up. We'd delved into parts of the brain that control everything, how well would he recover?"

Matthew did wake up, but had no sensation on his right side. His mum shared: *"I was thinking is he going to be able to walk. Will my Matthew still be my Matthew?"*. After intense daily physio, Matthew started to show progress, gaining sensation in his legs. Three weeks after surgery he went home and is continuing to recover well.



"I get surprised every day, that's why I love my job. Children have an incredible ability to repair like adults can't. You can do some extraordinary things and children will recover. Everything we do in neurosurgery is life changing. You are affecting the very soul of this person. Their future. Who they are. The stakes are very high and that's really hard, when you're dealing with children who have their whole lives ahead of them.

"A few years ago, Matthew's surgery would not have been possible. We are right at the cusp of what is possible. The iMRI would have been of significant benefit for Matthew. It is difficult through such a small opening to know where vital structures are. It could have helped me avoid the blood vessel. It may have helped us confidently push surgery further to remove more tumour. It would have saved Matthew days in the Paediatric Intensive Care Unit. Surgery would have been safer and his journey faster."

Aabir Chakraborty, Lead Neurosurgeon

A Channel 4 documentary "Brain Surgeon's: Between life and death" shares Matthew's story:
https://www.channel4.com/programmes/brain-surgeons-between-life-and-death/on-demand/70819-001

Distinct funding opportunities

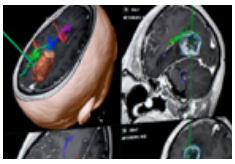
£410,000 - 50% of the MRI scanner

A grant at this level could add significant leverage to a proposal to a private philanthropist who would be likely to match this sum if it were *finishing off the* funding for this main piece of equipment. This 1.5T Tesla MRI scanner (Siemen's MR Nexaris 1.5T combination neurosurgery system) will have the latest software and techniques, offering high definition images and real-time information. The specific choice of scanner provides the most efficient and flexible use, providing high quality diagnostic imaging within an acute setting.

£300,000 - Faraday cage

Radiofrequency (RF) shielding, is installed in the walls, floor and ceiling of the scanner room. MRI is based on detecting tiny RF signals from within the body and this shielding is installed to prevent the scanner detecting external RF signals (e.g. mobile phone signals, electrical signals, electromagnetic interference from other equipment) that would cause interference in images and render them non-diagnostic. The shielding also prevents interference from the scanner affecting equipment in adjacent rooms, which allows the operating theatre to function as normal right next to the scan room, thus reducing the distance between the operating space and scanner to a minimum. This is essential for intra-operative work as the patient will be transferred between the two whilst still asleep on the operating table. The purchase/installation of this shielding will be the first element of charitable spend required to enable the rest of the project to be delivered.

£300,000 - Advanced neuro approach planning and navigation software



This high specification Brainlab software will enable the robust use of MRI images for specialist intra-operative neuro scanning and is one of the most advanced available globally. During a "normal" diagnostic MRI procedure there is opportunity to acquire several scan sequences which can be optimised to obtain the required detail and information. That is the strength of MRI - it can provide lots of different types of information about the structure and function of the brain. The interpretation of all these images is performed by a radiologist, prior to surgery, with time and expertise to hand. The Brainlab software will enable detailed advanced visualisation, directly by the neurosurgeon, of the more constrained set of images that will be acquired during surgery - thus enhancing the time-critical diagnostic and treatment planning information that needs to be obtained in this pressured environment.

This software is specifically designed to deliver the high-resolution and complex information that the surgeons require - robustly and quickly. Speed is essential whilst the patient remains asleep so they can then continue with surgery promptly. The software allows live, precision images to guide surgery to enable neurosurgeons to push the boundaries to achieve better patient outcomes, safely. A specialist microscope enables visualisation of the MRI images, super-imposed on the brain, during the operation, revealing residual tumour hidden behind healthy tissue.

This software is also critical to the augmented reality innovation. The MRI scan is superimposed directly onto the 3D space where the brain is, this allows the surgeon to plan the best approach during surgery (e.g. avoiding blood vessels) and allows the surgeon to see white matter tracks (derived from MR tractography images) so their approach avoids injuring healthy tissue. This also enables the next generation of neurosurgeons to track the routes they would choose to take, without practicing on a patient (which could have implications) and watch exactly what a surgeon is doing on a screen.

£217,000: All *'MRI conditional'* specialist equipment

A gift at this level could provide all major equipment required for intra-operative scanning - theatre table (£120k, see below), cardiac monitoring system (£62k) and contrast injector (£35k). The contrast injector injects dye into the brain to enhance visibility on scans, crucially it does this quickly and with accuracy to ensure absolute confidence that the surgeon is acting on precise information. The cardiac system enables continuous monitoring of the patients heart during surgery, transfer and scanning. All equipment is highly specialist to ensure it is not dangerously attracted to the MRI magnet when the integral doors are opened.

£120,000 - Theatre table and transfer/docking system

This specialist MRI compatible system allows the child to quickly and seamlessly move from the operating theatre into the scanner during surgery. The built-in shuttle system allows the child to be scanned without leaving the operating table and whilst their head remains in exactly the right position.

Innovation

Intra-operative MRI is transformational technology, enabling neurosurgeons to push surgery much further than has ever been possible, crucially, without risking irreparable harm to the child. However, the iMRI Suite will also provide infrastructure that provides a plethora of data and precision live images that will facilitate advances beyond that which is currently possible.

The team aim to develop and validate both the MR imaging techniques that they use, to augment these treatment approaches, as well as the analysis of the images acquired, using a variety of techniques including artificial intelligence and machine learning. The eventual aim will be to optimise intra-operative imaging, improve treatment planning and predict outcomes – all of which will lead to improved care and management of patients. The following innovations will increase survival rates and improve quality of life through safer, more effective treatment, whilst providing a wider range of clinical options.

Augmented reality (AR):

The iMRI will enable neurosurgeons to pioneer the application of AR in brain surgery. This may give the most intuitive surgical guidance ever achieved, dramatically increasing survival rates and improving quality of life for both children and adults. Goggles give a smart view of the patient with live graphics of anatomical structures from iMRI data.

AR will enable simulation before surgery to identify the best possible approach and, during surgery, it will enable surgeons to plan the best/safest way to remove residual tumour. The Southampton neurosurgeons believe augmented reality will be the most important adjunct in the future of neurosurgical simulation training. It is also likely to have applications beyond neurosurgery, particularly in simulation of complex operations within a wide range of paediatric and adult specialisms. If successful, the aim would be for the UK's eBrain training programme to implement AR as part of their programme for all trainees.

Trans cranial high intensity focused ultrasound:

Data provided through intra-operative imaging will also enable a cutting edge technique - MRI guided trans cranial high intensity focused ultrasound. This will significantly improve outcomes for thalamotomies (a surgical procedure in a region of the brain called the thalamus). The new technique will be used to more effectively treat tumours and potentially help make chemotherapy in the brain work better. It will also be used to improve outcomes for other conditions such as movement disorders, like tremors.

The potential is huge; it would enable surgeons to focus on a specific tumour or part of the brain with multiple ultrasound signals and kill off those parts of the brain. It would have applications for epilepsy, Parkinsons, OCD, radio/chemo resistant tumours etc. University Hospital Southampton would become the second centre in the UK to have this ultrasound addition. The hospital would become a reference centre in the UK/and beyond - a centre for other NHS Trusts/hospitals to reference the work delivered as extremely novel. University Hospital Southampton are the European leads for cryotherapy of tumours and could potentially lead for high intensity focused ultrasound if the iMRI Suite is realised.

Future plans, subject to funding:

Research using artificial intelligence could help classify abnormal tissue (e.g. tumours) that appears normal to the naked eye, predict patient outcomes, guide what would be the optimal treatment and accurately diagnose complex mental health disorders. The iMRI could also enable further innovation through robotic surgery, intra-operative CT, 3D neuro-endoscopy and digital surgical microscope.

"We are working right at the cusp of what is possible in paediatric neurosurgery. Intra-operative MRI technology is transformational itself, meaning we can push surgery further than ever before, but the innovation it will facilitate could reshape neurosurgery globally." Aabir Chakraborty, Lead Neurosurgeon

Clinical and research leads

Neurosurgeons will be supported by expertise in neuroradiology, MRI Physics, image processing and AI, both at UHS and in collaboration with colleagues at the University of Southampton.

- Joint clinical lead: Paul Grundy - Deputy Medical Director, Consultant Neurosurgeon and National lead for neurological service transformation programme (NHS England). Paul 's bio can be found here.
- Joint clinical lead: Aabir Chakraborty - Clinical Lead for Neurosurgery. Aabir's bio can be found here.
- Scientific lead: Angela Darekar - Lead for MRI Physics. Angela's bio can be found here.
- Trans cranial US lead: Girish Vajramani - Consultant Neurosurgeon. Girish's bio can be found here.

How outcomes will be measured

Impact measurement will encompass a mix of quantitive and qualitative data, using systems already in place within the NHS Trust to compare current data with data after the iMRI is operational - as well as developing additional surveys to capture further information. The plan includes:

- Number/percentage of children having one operation v multiple operations
- Shortest/longest and average number of days a child stays in the Paediatric Intensive Care Unit after an operation/between multiple operations
- Number of general anaesthetics and shortest/longest and average number of days of sedation - and resultant reduction in risk
- Shortest/longest and average number of days a child stays in hospital
- Number/percentage of operations extended due to new information provided by iMRI during surgery
- Average and maximum number of times the MRI is used intra-operatively
- Increase in number of children having surgery annually through increased capacity created and provision of cutting edge technology, particularly within wider network (e.g. Brighton, Oxford)
- Number of complete resections of tumours - leading to increased survival rates

Wellbeing surveys will aim to evaluate patient and family experience. This will be for the core group of children undergoing neurosurgery within the iMRI, but also for children/parents who will benefit from paediatric diagnostic scanning and for all adult inpatient scanning that will also be moved into the facility. Measures will focus on key themes on anxiety/stress and privacy/dignity:

- Know surgery outcomes on same day, reduced need for multiple operations
- Child friendly environment including distraction equipment/artwork
- Calmer, quieter and more appropriate environment
- Integrated facility reducing patient transfer/movement

Wider outcomes will be measured:

- Additional hours of routine and diagnostic scanning capacity annually for adults/children, equating number of patients and resultant reduction in waiting times (including for diagnosis/treatment)
- Additional number of MRI guided interventions for adults/children
- Additional capacity created within the Paediatric Intensive Care Unit

Augmented reality (AR), anticipated outcomes include:

- Improved planning/preparation for complex procedures, thus improved decision making intra-operatively
- Improved understanding of complex anatomy to enhanced specialist surgical training

Transcranial high intensity focused ultrasound, anticipated outcomes include:

- Successful outcomes for treatment of specific tumours
- Improvement of tremor measures
- Reduction of need for more invasive procedures to treat tremors, providing a safer surgical approach to treatment of essential tremor

A catalyst for change

Many neurosurgeons at University Hospital Southampton pioneered procedures that are now mainstream globally (e.g. endoscopic pituitary surgery, day case brain biopsy). The hospital were the first centre in the UK to implement MRI-guided prostate cryoablation. The innovation facilitated by this project is likely to be a similar catalyst for change to improve survival and quality of life for children needing neurosurgery and for adult and child patients with a vast range of wider clinical presentations e.g. Parkinson's disease.

Just seven children's hospitals in the UK have intra-operative MRI. These provide an existing network through which to share learning and this facility/clinical team will further add to this. It is the additional innovation that will translate from the provision of this new infrastructure that provides the most exciting potential as a catalyst for change.

University Hospital Southampton is looking to foster and catalyse research and innovation links through its Southampton Emerging Therapies and Technology Centre (SETT Centre) – with a focus on NHS needs in emerging areas, with vanguard potential for clinical services. This project fits within this scope. Collaborating with equipment and software manufacturers will enable us to develop and publicise the work, through joint grant applications and commercial trials, for example. The hospital is the largest Siemens Radiology Managed Equipment Service in the UK. The iMRI project allows this solid working relationship to develop further for the benefit of patients.

The hospital are well versed in sharing learning and enabling others to replicate practice. They would disseminate these finding regionally, nationally and internationally, as they already do for other areas of research and innovation. They are well connected to colleagues across the UK and internationally and would use their professional and research networks to share their learning from this work. Wider mechanisms for sharing learning through established links include:

- Neurological Service Transformation Programme (NHS England)
- Formal neuroscience network with Oxford University Hospitals NHS Foundation Trust and Brighton and Sussex University Hospitals NHS Trust.
- National Neurosurgical Training Network can introduce augmented reality into training to replicate practice for wider benefit
- Present and publish research/learning at national and international conferences
- World Federation Neurosurgical Societies
- American Association of Neurological Surgeons
- Society British Neurosurgeons
- British Paediatric Neurosurgery Research Group
- British Journal of Neurosurgery
- Institute of Physics and Engineering in Medicine

The potential barriers to the replication of the iMRI within other UK children's hospitals are largely related to financial and estate constraints. These suites require an extensive area within a hospital's theatre complex, often requiring a new build/extension to the existing estate. Every existing iMRI in the UK has required significant charitable funding alongside NHS investment, with total costs for some facilities up to £15m. The feasibility of fundraising success within charities linked with a hospital, alongside capital budgets within an NHS Trust, are both potential barriers.

The replication of the innovation is related to how robust measurement processes are to provide evidence of effectiveness and how this learning is disseminated. Subsequently, the barrier may be financial budgets for implementation or organisational contextual constraints within other hospitals. University Hospital Southampton's inter-organisational and network relationships are considered to be very strong and the clinical and scientific leads regularly work proactively as innovation champions to support implementation within different contexts. These two strengths are considered to be an integral part of the process of successfully developing, establishing and diffusing innovation.

Thank you

We know you have had some very high quality expressions of interest this year, so we are truly grateful that our project has been shortlisted, thank you. Should we be successful, we would be delighted to discuss recognition for a significant gift within the iMRI Suite. An example of one part of the recognition provided for INEOS/Sir Jim Ratcliffe's £500,000 donation to the Children's Emergency Department is pictured.

We look forward to welcoming you to the hospital this Autumn and introducing you to some of the people involved in the project. We are honoured to be shortlisted and hope you may feel in a position to help us accelerate this important project.

James Murray and Sarah Parish
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