Aberdeen's Role in the Development of Magnetic Resonance Imaging

Nuclear Magnetic Resonance, or Magnetic Resonance Imaging (MRI) as we now know it, was first jointly proposed in 1973 by Paul Lauterbur at Stony Brook New York, and Peter Mansfield in Nottingham. Lauterbur demonstrated his method by imaging a pair of test tubes, while Mansfield's team initially imaged fruit. Scaling up MRI to image living humans in a reasonable time frame would subsequently require years of research, and Aberdeen researchers played a pivotal role.

In the late 1950s and early 1960s John Mallard was in London working on nuclear medicine and its clinical applications. He developed an interest in magnetic resonance and put together an electron spin resonance (ESR) spectrometer. MRI is based on nuclear magnetic resonance – a closely related technique. Mallard showed that ESR signals from normal tissue were different from those from tumours. He moved to Aberdeen in 1965 to take up the new post of Professor of Medical Physics, taking his ESR equipment with him.

In the early 1970s, Prof. Mallard appointed Jim Hutchison to his team, who had done his PhD on ESR at the University of St Andrews. He designed and built a prototype MRI scanner based on Lauterbur's and Mansfield's ideas. The scanner was successfully used to scan a dead mouse in 1975, the first time that "pathology" had been imaged by MRI!

Following the mouse-scanning success, John Mallard succeeded in obtaining a grant from the Medical Research Council which enabled Jim Hutchison and team to design and build a human-sized MRI scanner, based on a 0.04 tesla magnet which was delivered to Aberdeen in 1977. The team was joined by Bill Edelstein from USA (1978), by PhD students Glyn Johnson (1978) and Tom Redpath (1979).

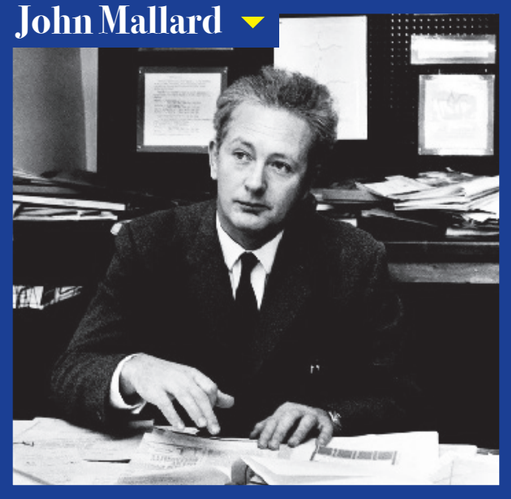
This team, working with Eddie Stevenson in the department's mechanical workshop, built the Mark 1 MRI scanner, the world's first working whole-body MRI scanner. That machine is now on display in the Suttie Art Space between Phases 1 and 2 in Aberdeen Royal Infirmary.

Early images were prone to artefacts but the team invented a "spin warp" technique which enabled artifact-free images of live humans to be produced. The first patient was scanned on 28th August 1980.

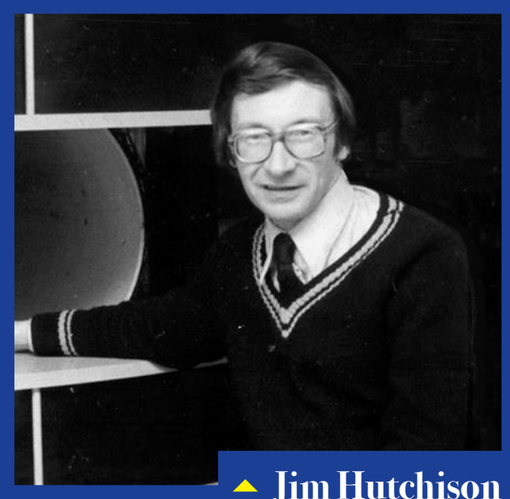
Many others were to follow, with Dr Francis Smith leading the research into the clinical applications of MRI. Spin-warp is still the standard method of forming images and is used by all scanner manufacturers and hospitals worldwide.

A number of "Mark 2" scanners (0.08 tesla magnetic field strength) were built in Aberdeen by a local company set up by John Mallard. One is now in the Royal Scottish Museum in Edinburgh, and one is in the Science Museum in London. Scores of scanners based on the Mark 2 design were built and sold by Asahi in Japan.

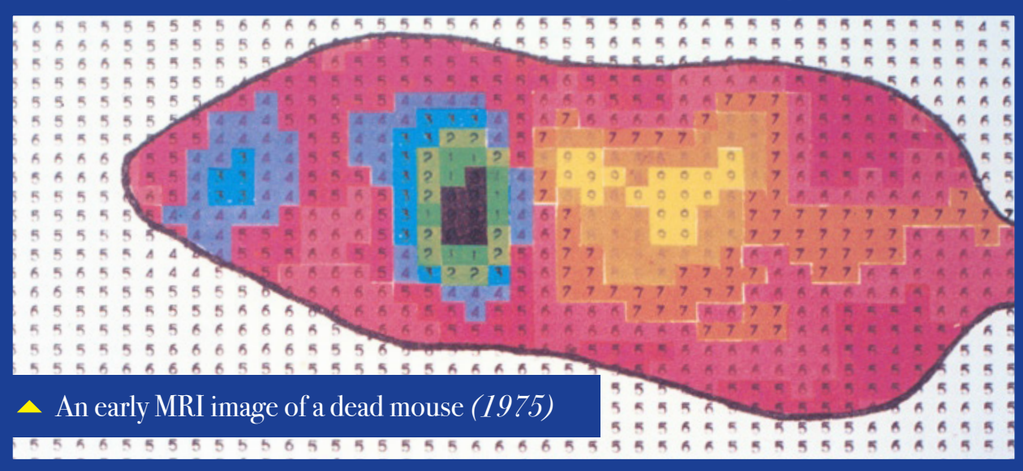
The team received many awards and John Mallard has donated his medals to the Aberdeen Medico-Chirurgical Society. He also donated money for this display case where the medals will be exhibited.



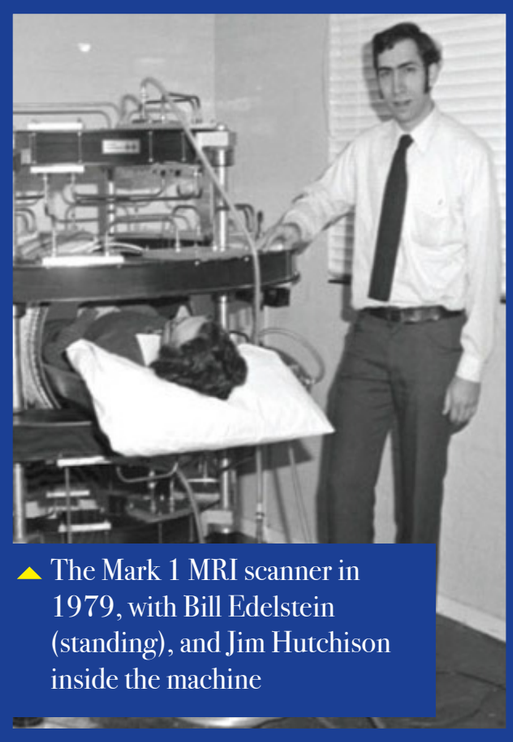
John Mallard



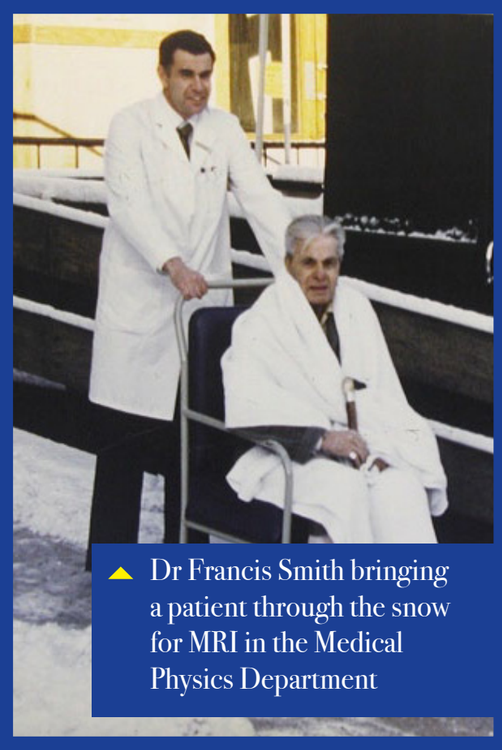
Jim Hutchison



An early MRI image of a dead mouse *(1975)*

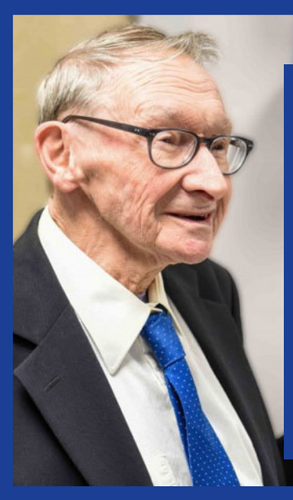


The Mark 1 MRI scanner in 1979, with Bill Edelstein (standing), and Jim Hutchison inside the machine



Dr Francis Smith bringing a patient through the snow for MRI in the Medical Physics Department

The MRI team circa 1982, including Dr Linda Eastwood (front) who had replaced Bill Edelstein following his departure to GE in the USA, and three Japanese engineers seconded from Asahi Chemical Industries, which funded the Mark-2 scanner construction.



Professor John Mallard, furthest left, with the insignia of the Officer of the British Empire (OBE)

Professor Jim Hutchison, left. The 'Hutchison MRI Centre'at Woodend Hospital is named after him and his wife, Meg

Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI) uses a strong magnetic field and a radio transmitter to produce radio signals from water and lipid molecules in the soft tissues of the body. The signals actually come from the magnetic nuclei of the hydrogen atoms (i.e. protons) in these molecules.

The first MRI machine used a water-cooled magnet with a strength of 0.04 tesla - the SI unit of magnetic flux density. Modern scanners use much stronger magnets with magnetic fields of between 1.5 and 3 tesla (1.5 – 3.0 T).

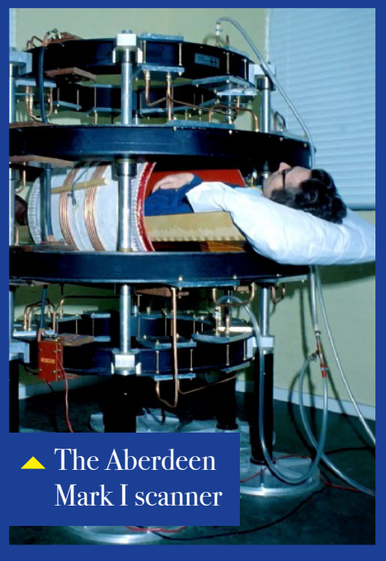
The development of the 'spin warp' technique by Aberdeen scientists (see the other poster) enabled the whole body to be scanned in a much shorter time, without significant artefacts, thus enabling normal and diseased human tissues to be usefully imaged for the first time.

Mark 2 was the second MRI prototype and used a stronger field of 0.08 T. That imager was installed in ARI in late 1982 and enabled the clinical usefulness of this new imaging technique to be explored. Cardiac imaging and applications in cancer and neurology were the focus of many research projects. The "Magiscan" fund raising appeal allowed NHS Grampian to install its first commercial Siemens 1.0T MRI scanner in 1992, replacing Mark 2.

In 2000 with support from the Scottish Government, the University of Aberdeen installed their first 1.5T General Electric clinical MRI scanner, dedicated to research, with a donation from the Roland Sutton Academic Trust funding construction of the Lilian Sutton Building. In 2007 the 1.5T scanner was replaced with a Philips 3T scanner installed in the same building as the Siemens scanner in 1992.

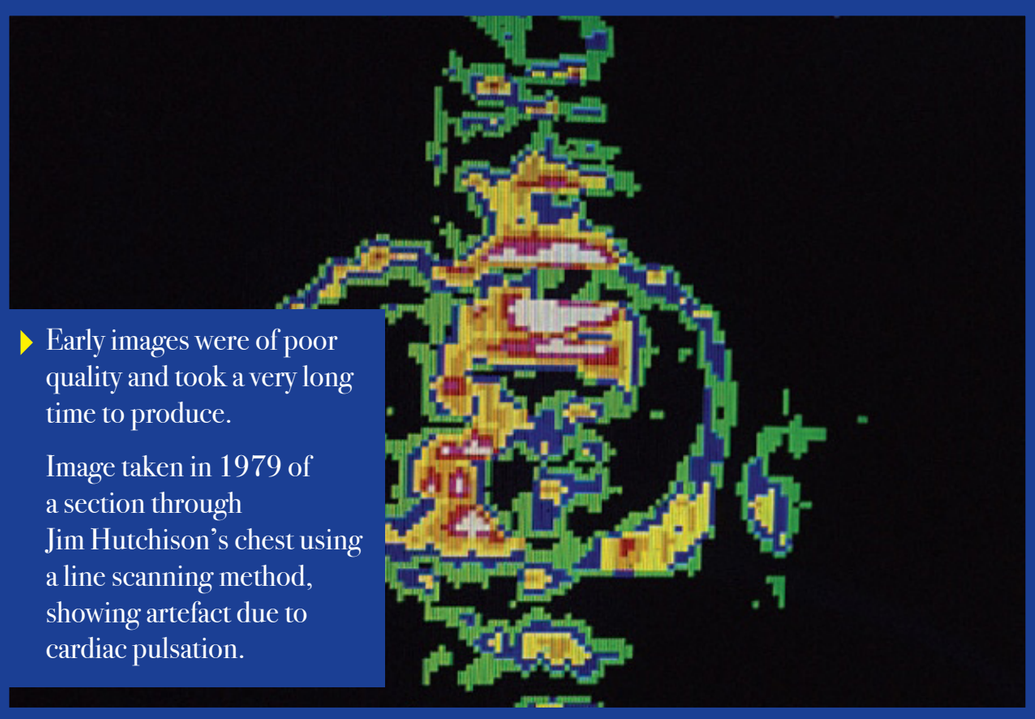
A comprehensive upgrade to the 3T MRI scanner is the latest phase of a 40-year commitment by the University of Aberdeen, in collaboration with NHS Grampian, to clinical imaging research and the development of MRI. Close connections with industry have provided state-of-the-art capabilities to the biomedical imaging research community at the University of Aberdeen. We are part of a worldwide network of leading researchers, enabling us to access the most modern and effective imaging tools.

University of Aberdeen researchers remain at the forefront of research. Over the last decade they have developed a new kind of MRI scanner, called "Fast Field-Cycling". By switching its magnetic field rapidly between different magnetic field strengths, the scanner is able to provide extra information which may lead to earlier, more accurate diagnosis. The scanner has already been used to image patients with a range of conditions, including stroke (see below) and cancer.



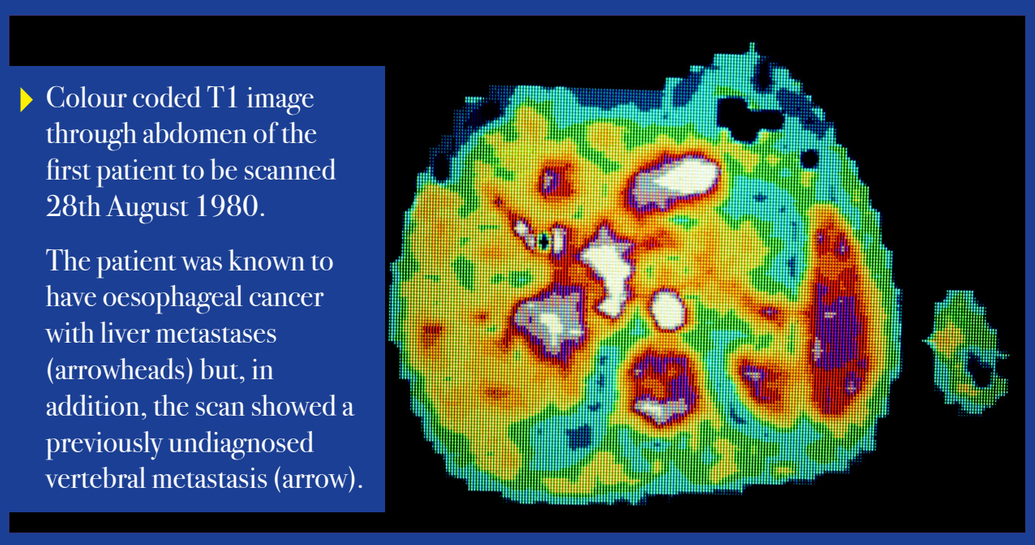
▲ The Aberdeen Mark I scanner

▲ Modern 3T MRI scanner



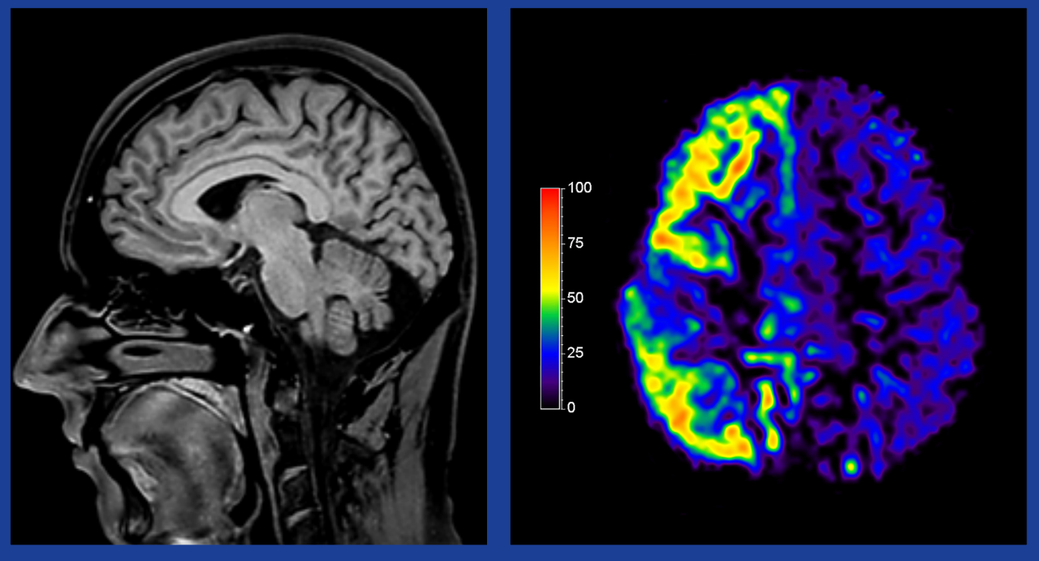
▶ Early images were of poor quality and took a very long time to produce.

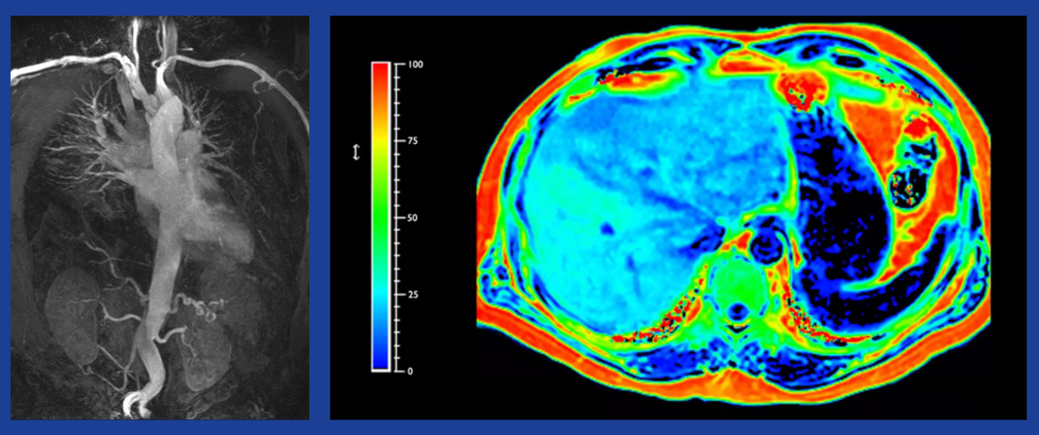
Image taken in 1979 of a section through Jim Hutchison's chest using a line scanning method, showing artefact due to cardiac pulsation.



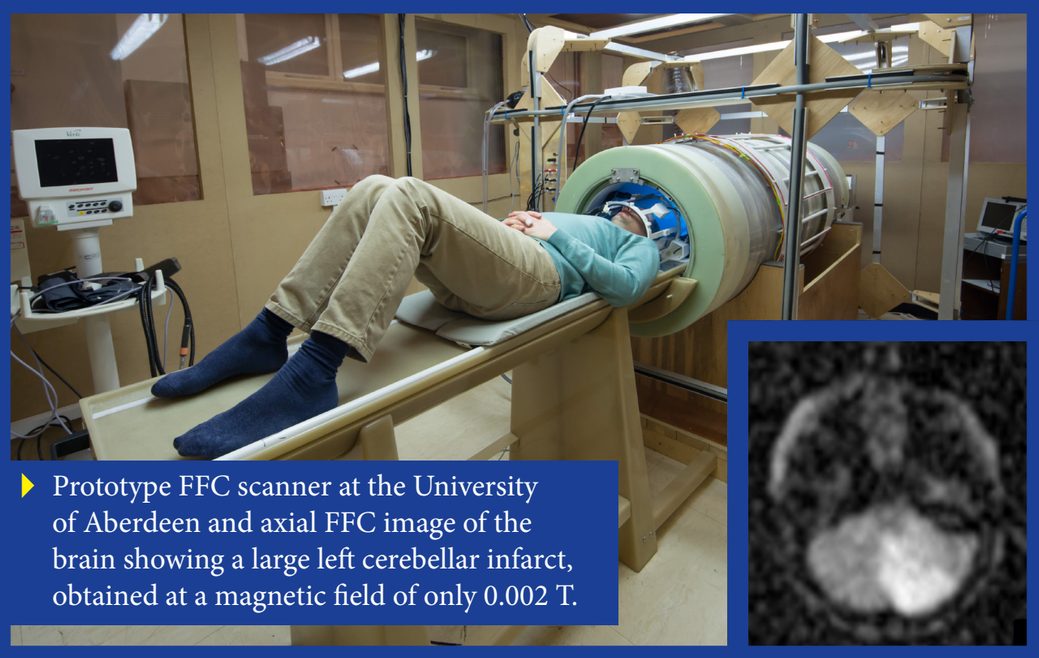
▶ Colour coded T1 image through abdomen of the first patient to be scanned 28th August 1980.

The patient was known to have oesophageal cancer with liver metastases (arrowheads) but, in addition, the scan showed a previously undiagnosed vertebral metastasis (arrow).





▲ Modern MRI examples, clockwise from top left: T1 sagittal brain; axial arterial spin labelling of blood flow in right side of brain post stroke; coronal MR angiogram of heart and great vessels; axial image of liver and upper abdomen to measure fat content .



▶ Prototype FFC scanner at the University of Aberdeen and axial FFC image of the brain showing a large left cerebellar infarct, obtained at a magnetic field of only 0.002 T.