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SPECIAL REPORT: MRI - THE FUTURE OF DIAGNOSTICS

The first patent for magnetic resonance imaging technology (MRI) was filed in the 1960s. But it was several decades later that it started to gain traction in the UK healthcare market. Now MRI scanning is the gold standard for diagnostics across many medical specialties. In this article *BBH* editor, **Jo Makosinski**, looks at how it is impacting patient pathways and how manufacturers are responding to an increasing demand with new innovations.

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Late last year the NHS published the *Diagnostics*: *Recovery and Renewal Report*, which recommends a new service model with more facilities in free-standing locations away from main hospital sites, including in high streets and retail locations, providing quicker and easier access to a wide range of diagnostic tests.

This approach is even more important in light of the COVID-19 pandemic and the desire to keep patients out of acute hospital environments.

And one of the most-vital modern-day diagnostic tools is magnetic resonance imaging (MRI), which the report singles out as an area for significant capital investment moving forwards.

It states that, between 2014/15 and 2018/19, MRI activity increased, on average, by 5.6% a year; with 3.6 million scans undertaken every 12 months.

But, despite this growth, England lags behind OECD averages for the number of available scanners relative to population, with figures showing there are less than 0.1 scanners per 10,000 people.

And the number of patients waiting more than six weeks for a diagnostic test increased markedly between 2017-2019.

Furthermore, the median time to report MRI scans was three days, according to the report, and it highlights wide variation across the country.

With significant further demand predicted in the coming years, there is a clear shortfall in scanning technology.

Quicker and quieter

The report estimates that the requirement for MRI scanners is an additional 273 machines across England over the next five years, and the

WHAT IS MRI AND HOW DOES IT WORK?

Magnetic resonance imaging (MRI) is a type of scan that uses strong magnetic fields and radio waves to produce detailed images of the inside of the body.

The scanner is basically a large tube that contains powerful magnets and patients lie inside the tube during the scan. Most of the human body is made up of water molecules, which consist of hydrogen and oxygen atoms.

And, at the centre of each hydrogen atom is an even-smaller particle called a proton, which are like tiny magnets and are very sensitive to magnetic fields.

When you lie under the powerful MRI scanner magnets, the protons in your body line up in the same direction, in the same way that a magnet can pull the needle of a compass.

Short bursts of radio waves are then sent to certain areas of the body, knocking the protons out of alignment. When the radio waves are turned off, the protons realign.

This sends out radio signals, which are picked up by receivers.

These signals provide information about the exact location of the protons in the body.

They also help to distinguish between the various types of tissue in the body, because the protons in different types of tissue realign at different speeds and produce distinct signals.

In the same way that millions of pixels on a computer screen can create complex pictures, the signals from the millions of protons in the body are combined to create a detailed image of the inside of the body.

An MRI scan can be used to examine almost any part of the body, including the brain and spinal cord, bones and joints, breasts, heart and blood vessels, internal organs, such as the liver, womb or prostate gland and the results can help to diagnose conditions, plan treatments and assess how effective previous treatment has been.

Extensive research has been carried out into whether the magnetic fields and radio waves used during MRI scans could pose a risk to the human body.

But no evidence has been found to suggest there is a risk, which means MRI scans are one of the safest medical procedures available.

But they may not be recommended in certain situations, for example, if a patient has a metal implant fitted, such as a pacemaker or artificial joint.

Alison Kenny, GE Healthcare MR modality manager, said: "MRI is a powerful imaging modality, used for disease detection, diagnosis, and treatment monitoring.

"It is particularly well suited to image soft tissue, such as the brain, the spine and joints and MRI scanners are particularly well suited to image the non-bony parts or soft tissues of the body.

"Because MRI does not use ionising radiation, it is the imaging modality of choice when frequent imaging is required for diagnosis or therapy, especially in the brain."

MRI is the gold standard for diagnostics in many medical specialties

replacement, or upgrade, of 193 others.

The report states: "Expansion of imaging equipment and facilities to meet anticipated demand, combined with replacement of old machines, is clearly much needed."

And it says MRI scanning equipment should 'as a minimum, be expanded in line with growth rates prior to the pandemic and all imaging equipment older than 10 years should be replaced'.

With this intended level of investment, the pressure is now on manufacturers to provide the very latest in MRI technology.

Vanessa Ellis, MR modality manager at Canon Medical Systems, said: "MRI physics hasn't changed over the years, but scanners have become quicker and quieter and functionality has become more automatic to assist with imaging workflow, and the range of clinical application packages have expanded."

The biggest and most-recent revolution has been image noise reduction to improve MRI picture quality.

This has been powered by Canon's Advanced intelligent Clear-IQ Engine (AiCE), the world's-first MR Deep Learning reconstruction technology, which was first introduced to its CT products and has now expanded to MRI.

No compromise

It overcomes the traditional compromise between signal, image resolution, and speed, intelligently removing the graininess caused by noise to provide exceptionally-detailed images that enhance clinical diagnosis.

Ellis said: "Being able to see a pathology more clearly is positively changing patient pathways in healthcare.

"And a more-confident diagnosis means that other procedures are not needed, and that has time and health economic benefits."

Alison Kenny, GE Healthcare's MR modality manager, adds: "Scans are becoming faster, and therefore more comfortable for patients and better for throughput and workflow, with innovations such as AIR Recon DL.

"This new tech is the MR industry's first deep-learning-based image reconstruction technology that works across all anatomies.

"Using a deep learning-based neural network, AIR Recon DL improves the patient experience through shorter scan times while also increasing diagnostic confidence with better image quality across all anatomies."

Improving the patient experience is also driving R&D in the field.

EXPANSION OF IMAGING EQUIPMENT AND FACILITIES TO MEET ANTICIPATED DEMAND IS CLEARLY MUCH NEEDED

"Wider and shorter bore holes have been introduced by the imaging industry over to the last decade to reduce claustrophobia and patient anxiety," explains Ellis.

"Innovation has continued on patient comfort and now acoustic noise reduction technology through our 'Pianissimo' innovation, for example, is making scans quieter and more efficient.

"A quieter scan helps reduce the anxiety of some patients, resulting in better patient experience. Furthermore, encouraging patients to relax and stay still also enhances image quality.

"Further enhancements include our immersive MR Theatre on the Vantage Orian 1.5T and Vantage Galan 3T MRI scanners which gives patients an engaging visual focal point to distract them from their examination."

Speeding up

A spokesman for Philips adds: "Out of all the primary imaging modalities, MR has certainly evolved the most, both in terms of capacity, and the increase in the range of examinations as technology has progressed.

"Improved hardware and software development has seen a vast improvement in the speed of acquisition, with revolutionary techniques, such as Philips compressed SENSE, seeing up to a 50% reduction in scan times.

"Modern wide-bore systems with enhanced patient features also ensure the patient is comfortable and therefore at ease, leading to improved tolerance to scans with a reduction in repeat scans.

"All of these advancements lead to an increased confidence in diagnosis, leading to improved patient outcomes."

To meet the report's recommendations for both an increase in machines, and a shift to more-community-based locations, Canon offers both static systems for traditional hospital use, and mobile and relocatable units for use in community hubs and imaging centres.

While the diagnostics report favours bulk buying in order to bring down the huge cost of funding the necessary equipment; manufacturers are also working to reduce running costs and create efficiencies.

Ellis told *BBH*: "Capital cost and overall cost of ownership are vital factors in MRI procurement.

"We have looked in detail at reducing the long-term running costs of our MRI scanners for hospitals. For example, we have introduced 'ECO Mode' functionality that automatically puts the systems into standby mode between patients, reducing power consumption.

"This is a valuable factor in driving down energy costs and a key sustainability measure to reduce the carbon footprint of UK radiology."

More sustainable

In its R&D activity, Philips has also addressed the shortage of Helium, which has been traditionally used to maintain the magnetic field.

The spokesman said: "The most-recent advancement in MRI development is the unique Philips BlueSeal magnet, which only requires seven litres of Helium to operate, ensuring sustainability.

"If all standard 1500L scanners in the UK were replaced with BlueSeal magnet scanners, we estimate the total cost saving for the NHS would be £24.8m, so not only do these benefit the environment; they also enable NHS trusts to re-invest the saved money."

When specifying new machines, he advises: "There are many factors to consider, but primarily image quality and speed of acquisition is likely the initial consideration.

"As technology has advanced so quickly in MR, it is vital to evaluate those changes and how these could improve, or enhance, diagnosis and therefore these new techniques should be

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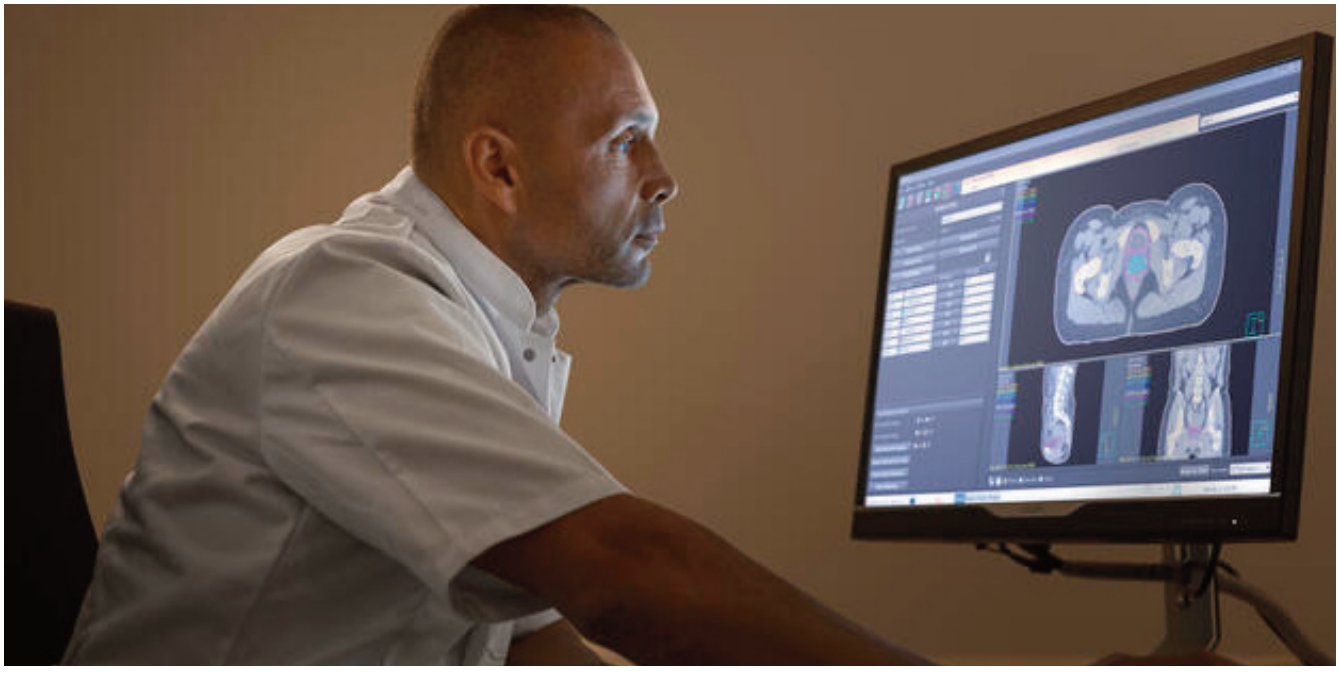

considered and evaluated when specifying any new system.

"And, with many clinical staff often rotating through more than one modality; ease of use and the implementation of smart workflow solutions can help to guide staff through examinations and therefore improve consistency and confidence.

"In the current climate it is also imperative that a sustainable solution is considered."

Kenny adds: "Fast install times are imperative to reducing downtime, where possible, and strong support services are usually desired; for example, service and education for all radiographers and radiologists."

Moving forwards, manufacturers are looking to further reduce cost and improve performance.

Artificial intelligence

Ellis said: "Artificial Intelligence (AI) is undoubtedly key to the advancement in MRI.

"It is already in place in UK MRI scanning, via our Advanced intelligent Clear-IQ Engine, and is helping to change patient pathways for the better.

"However, we don't stand still, so we're working on the next versions that will deliver even more improvements to reduce image noise and improve image quality."

AI will also shape the evolution in workflow and help overcome some of the challenges posed by a shortage of MRI radiographers.

"Automating processes and using AI-assisted technology for clinical image reporting are just some of the ways this is possible," said Ellis.

"Our Canon Medical Research Europe hub is based in Edinburgh, so the UK is at the heart of our AI innovation strategy, and we are committed to driving forward advancements in AI that will deliver next-generation medical imaging to change lives."

The Philips spokesman adds: "We will see further improvements in speed and accuracy with the integration of developing artificial intelligence protocols to reduce repetitive tasks.

"MR will also continue to develop as a key diagnostic tool, but further expansion into the treatment and therapy pathways is the area where there is the most growth and opportunity."

Kenny concludes: "The future for MR is bright - it's really an exciting time to be in this field.

"MR is getting smarter, faster, into new research fields, and available to more patients.

"We see MR research being pushed to new boundaries such as neurodegenerative diseases.

"Access is also being improved, with wide-bore, faster scans, improved comfort, and new or growing applications.

"And AI is bringing new opportunities to make MR faster, more productive, and more quantitative.

"At GE, we call this future 'intelligent MR' and our vision is to make MR fast, consistent, quantifiable and personalised."

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