NPL
National Physical Laboratory

Phantom Metrology: Standardising MRI Scanners for Reliable Drug Trials

Magnetic Resonance Imaging (MRI) scanners are routinely used in hospitals to diagnose disease in the human body. Hospital radiologists review these patients' scans to assess the presence, shape, size and extent of lesions. MRI scanners are also invaluable in drug development, where they are used in clinical trials to measure how drug treatment is affecting the body. Clinical researchers running trials need quantifiable data where it is easy to see the intensity of that data as well as extent of disease. That could be a measurement of the rate of blood or oxygen reaching to a tumour, or what a lesion is composed of, beyond just its size, shape, and location. These quantified measurements from images are technically classed as "biomarkers".

This is Bioxydyn Limited's business – it helps pharmaceutical companies and academic research teams obtain and understand detailed quantifiable biomedical data from MR scans. Having spun out of the University of Manchester in 2009, Bioxydyn is now a world leader in the field of imaging biomarkers, and works with many of the largest pharmaceutical companies, biotechnology businesses, and with world-leading academic teams.

Challenge

Bioxydyn recognised a significant challenge to expanding the use of quantifiable MR in drug development: inconsistent imaging data across different makes and models of MRI scanners. This can make it hard to interpret the imaging data if a clinical trial recruits patients from many different hospitals around the world. Without rigorous quality control, hospitals with unreliable scanners might be permitted to participate in the trial, producing invalid data from the patients who have kindly consented to participate. Or a poorly designed quality control programme might exclude a perfectly good scanner from the trial, potentially resulting in perfectly good images being discarded.

Bioxydyn realised that the problem lay in the way that MRI test objects, known as phantoms, were being used. Phantoms have been employed for over 40 years in MRI. They are objects with known properties, which can be scanned, so that the scanner's measurements can be compared with the object's true values. The difficulty is that there is no rigorous way of deciding between quality control "pass" and "fail" for the intensive quantitative MRI measurements Bioxydyn needs to make.

"The way many organisations use phantoms had become performative – a superficial checkbox exercise where the phantom is scanned, but without a rigorous and transparent process for deciding whether that scan actually represents a pass or a fail," explains Professor John Waterton, Bioxydyn's Scientific Director. "We knew that solving this problem could speed up clinical trials for new drug treatments and improve the quality of the data. And that this would also offer our company a new competitive advantage."

Bioxydyn approached NPL through the M4B programme to partner on a way to enhance the use of phantoms by developing robust metrology methods and establish quantifiable imaging standards.

Solution

The project had two primary objectives:

1. **Scientific Rigour:** Develop a quantitative methodology for phantom-based imaging calibration that could be applied in those clinical trials subject to the most rigorous scientific and regulatory scrutiny.
2. **Commercial Edge:** Position Bioxydyn as an authority in MRI quantification, offering exceptional reliability and replicability to clients.

NPL's expertise in metrology and magnetic resonance physics was critical to achieving both. It also offered something else that meant it could deliver results much faster than anticipated – an unparalleled knowledge of existing technical documentation for industrial metrology procedures in other sectors. This mattered because the output of NPL and Bioxydyn's M4B project would be a technical procedure for using phantoms effectively. Knowing what was available in other fields, where there was already well-developed metrology for similar problems meant the project did not need to start from scratch.

"As an MR physicist and a metrologist, I could understand the problem and possible ways to achieve the objectives," explains Matt Hall, Science Area Leader for Nuclear Medicine and Magnetic Resonance Physics. "But our team's deep understanding of existing measurement procedures and supporting technical literature in other industries meant we could utilise our knowledge of what was already out there and adapt it for Bioxydyn's particular requirements. It was much quicker and based on proven approaches."

NPL used this combination of expertise to design a bespoke workflow for using phantoms that would facilitate more quantifiable MRI results. This included:

- Statistical analysis techniques that would quantify imaging data accurately
- Advanced equations to process data from phantoms and define a pass/fail threshold for scanners
- A systematic procedure for ensuring imaging consistency across multiple sites and scanner models.

The project was highly collaborative. Bioxydyn provided example data sets for NPL to use. NPL then ran test analyses using the different elements of its proposed procedure to see whether they delivered useful outputs. It would share the results with Bioxydyn, which would apply its commercial experience to guide NPL on whether the proposed approach would be effective in real drug development environments.

"This project emphasised practicality," suggests Professor Waterton. "We blended scientific precision with the flexibility to adapt to the commercial and medical realities of clinical trials. Together, NPL and Bioxydyn ensured the guidance we could now provide about using phantoms effectively was not only robust but also scalable for use in diverse trial environments."

Impact

As a result of this project, some of the largest pharma companies in the world are now talking to Bioxydyn about incorporating its metrology into their processes.

Firstly, it has enhanced Bioxydyn's capabilities, enabling it to offer clients a rigorous Phantom Metrology Plan designed for clinical trials. That is now a cornerstone of the company's proposition around quantifiable MRI protocols, ensuring imaging data is reliable and actionable. This is cementing Bioxydyn's position as the market leader in imaging biomarkers, driving discussions with new clients and creating pathways for future contracts.

The project's success also boosted existing clients' confidence in Bioxydyn. By developing these rigorous standards, and embedding them in its commercial proposition, the company has strengthened its reputation among pharmaceutical clients that are constantly seeking new ways to reduce data quality risks, ensuring trials are scientifically valid and ethically sound.

Beyond the immediate benefits for Bioxydyn, the workflow developed with NPL will be featured in peer-reviewed publications, setting a new industry benchmark f, and opening doors for applications in other sectors.

"This project has been about creating a new measurement process to enable faster medical discoveries that could save lives," concludes Hall. "We may have taken from what was already out there, but we are also giving something back to further expand the body of work that exists in the field. It's a superb demonstration of how M4B projects should work. This project highlights the critical intersection of science and commerce. By addressing longstanding gaps in quantifiable imaging standardisation, we have not only helped those conducting vital clinical trials but also demonstrated the transformative power of rigorous metrology."

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