Graphene-chip implant in UK trial could transform brain tumour surgery

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A revolutionary device designed to transform the surgical treatment of brain tumours is set to have its first clinical trial in what scientists say could be a major medical breakthrough.

The brain chip can pinpoint cancer cells through differences in their electrical emissions compared with those of healthy neural tissue.

The size of a postage stamp, the device is made of graphene, a material 200 times stronger than steel and only one atom thick. Graphene was invented 20 years ago by Manchester University scientists Andre Geim and Konstantin Novoselov, who later won the 2010 Nobel prize in physics for their research.

Scientists have since been working to exploit the remarkable conductive properties of graphene in order to develop new electrical and magnetic sensors and other devices. However, the flexible brain chip – now being trialled at Salford Royal hospital – is being hailed as a medical first. “This is the first ever clinical trial to be performed anywhere in the world with a graphene-based medical device,” said one of the team’s leaders, Kostas Kostarelos, a professor of nanomedicine at Manchester.

The brain-computer interface (BCI) device has been designed and fabricated by an international team of scientists in order to transform the monitoring of electrical impulses of cells in the brain by using frequencies that previously could not be detected. “Its first use will be to differentiate cancer cells from healthy cells to ensure that surgery on brain tumours is directed in a highly accurate way,” said Kostarelos.

Such a goal is of vital importance, doctors point out. More than 12,700 people are diagnosed as having brain tumours in the UK every year and more than 5,000 annual deaths are attributed to the condition. “Anything we can do to improve these rates will be a major achievement,” he added.

However, the team behind the BCI device also believes it will help scientists study many other conditions – including stroke and epilepsy – by giving them far greater understanding of how electrical signals are transmitted by healthy cells, compared to cells that are affected by pathological conditions.

“This is a clinical milestone that paves the way for advancements in both neural decoding and its application as a therapeutic intervention,” said Carolina Aguilar, co-founder of Inbrain Neuroelectronics, the global spin-off company that has been set up to exploit the use of graphene in brain research and treatment.

Cells in the brain interact by exchanging electrical impulses, a process that underlies our thoughts, behaviour, and perceptions of the world. Yet it has been a major headache for scientists to monitor exactly how these cells communicate in this way. “We can study some electrical signals that are emitted by brain cells. However, those of very low and very high frequency are very difficult to detect in the living brain,” said Kostarelos.

“Only those in middle-range frequencies can be monitored at present. Crucially, the BCI chip can pinpoint a huge range of electrical signals in the brain, including those of very high and very low frequencies.”

To use the device, a piece of a patient’s skull is removed and the tiny wafer-thin chip – which has thousands of electrical contacts – is placed on top of their brain. Transmitters send out electrical signals to stimulate the brain’s cells and the tiny receivers pick up their responses.

“Cancer cells do not respond to electrical stimulation set off by the chip in contrast to host neuronal cells,” said Kostarelos. “This allows a surgical team to identify neurons very close to a tumour and that is extremely important. If a tumour is located in parts of the brain such as those involved in speech, the team will need to be particularly careful. Guided by the signals from the graphene chip they can remove the diseased cells with more accuracy and confidence.”

The ability of the BCI chip to detect very high and very low frequency signals from brain cells is also important for other reasons. With strokes and epileptic fits, it is known that very low frequency signals are sent out by cells in affected parts of the brain and this technology opens up a new way to explore what happens immediately after a person suffers one of these events.

“The technology – which relies on graphene’s remarkable properties – is going to help to direct surgical interventions in the brain and also allow fundamental new understanding about how the cells in our brain function and interact in a diseased state,” said Kostarelos.

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