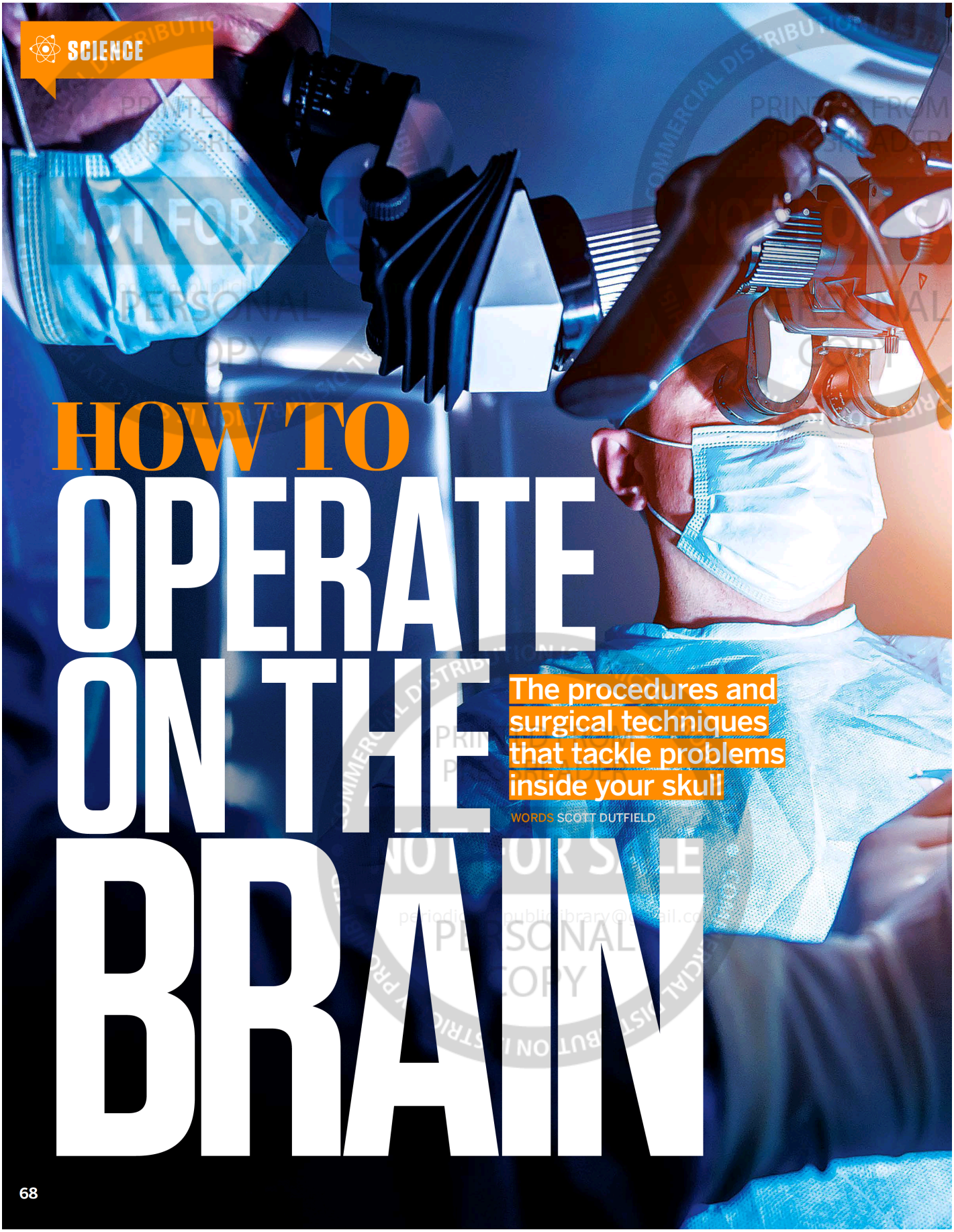
- Surgery / Brain



DID YOU KNOW? Genetics are to blame for less than five per cent of brain tumours

Brain surgery encompasses a myriad of procedures designed to treat an equally diverse set of conditions and associated symptoms, including tumours, blood clots, epilepsy and aneurysms. Neurosurgeries can range from minimally invasive procedures such as a biopsy, whereby a needle is inserted into the brain to collect cells for analysis, to extensive operations that expose the brain to treat blood clots and for tumour removal.

Like any other tumour, a brain tumour is an abnormal mass of cells and tissue that wedges itself somewhere in the brain. There are two categories of tumour: benign and malignant. While benign tumours can grow large, albeit slowly, they don't typically invade surrounding tissue or spread around the body. A malignant tumour, on the other hand, grows much faster, invades other tissue and can spread around the body. All in all, 120 different types of tumour can form in the brain alone.

For both benign and malignant brain tumours, a common course of intervention is a craniotomy and resection, whereby a surgeon removes a portion of the skull to expose the brain and hopefully cut away the tumour. To help guide them through the brain and keep tabs on where surgical instruments are during operations, surgeons use neuronavigation systems that are connected to their equipment. "One of the biggest challenges is distinguishing between normal brain tissue and tumour tissue, which requires extensive training and experience," says Pietro D'Urso, a consultant neurosurgeon at Salford Royal Hospital in Manchester. "The location of the tumour is another big challenge, particularly if a tumour is in very important parts of the brain, called 'eloquent areas', that control speech and motor functions."

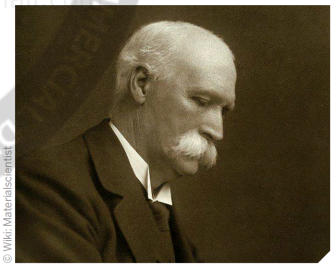
Did you know?

There are an estimated 49,940 neurosurgeons globally

In some cases, surgeons can access the brain without having to remove part of the

FIRST REMOVAL

At the Glasgow Royal Infirmary in 1879, pioneering surgeon William Macewen completed a landmark surgery to remove a brain tumour. 14-year-old Barbara Watson presented an "obscuration of intelligence, slowness of comprehension, want of mental vigour and pain in the head," according to Macewen's address to the annual meeting of the British Medical Association in 1888. Macewen identified a tumour in the dura, a thick membrane that surrounds the brain, now known as a meningioma. The tumour was compressing the brain, causing the patient's symptoms. After Macewen cut through the skull and removed the tumour, Watson made a full recovery.



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William Macewen, a pioneer of British brain surgery

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SCIENCE

skull by going through the nose or mouth. This type of procedure is called neuroendoscopy. Using a piece of equipment called an endoscope, which includes a tiny camera and light, surgeons can transverse the nasal passage up into the brain to treat tumours. "We use the endoscope when we feel that we can safely deal with the abnormality, respecting the surrounding brain structures, and at the same time when we believe we are able to effectively remove the cyst or tumour."

Unlike many other kinds of surgery, brain surgery can be carried out while the patient is unconscious or awake. Used to tackle tumours in specific areas of the brain that are involved in functions such as speech and memory, an awake craniotomy allows doctors to assess the functionality of the brain during surgery by getting patients to perform certain tasks. "Awake craniotomy is used to reduce the risk of causing permanent damage during the removal of a tumour, and usually patients undergoing an awake craniotomy recover quicker," says D'Urso.

However, if a patient feels uncomfortable with the idea of being awake during surgery, surgeons have other ways to assess brain function. "We can still proceed to remove tumours in eloquent areas, particularly the areas of the brain involved in the control of movement, using special electric probes that deliver a gentle current that stimulates the brain to map and monitor the motor functions," says D'Urso.

In the world of neurosurgery, D'Urso says that the "pace of technological advancement is

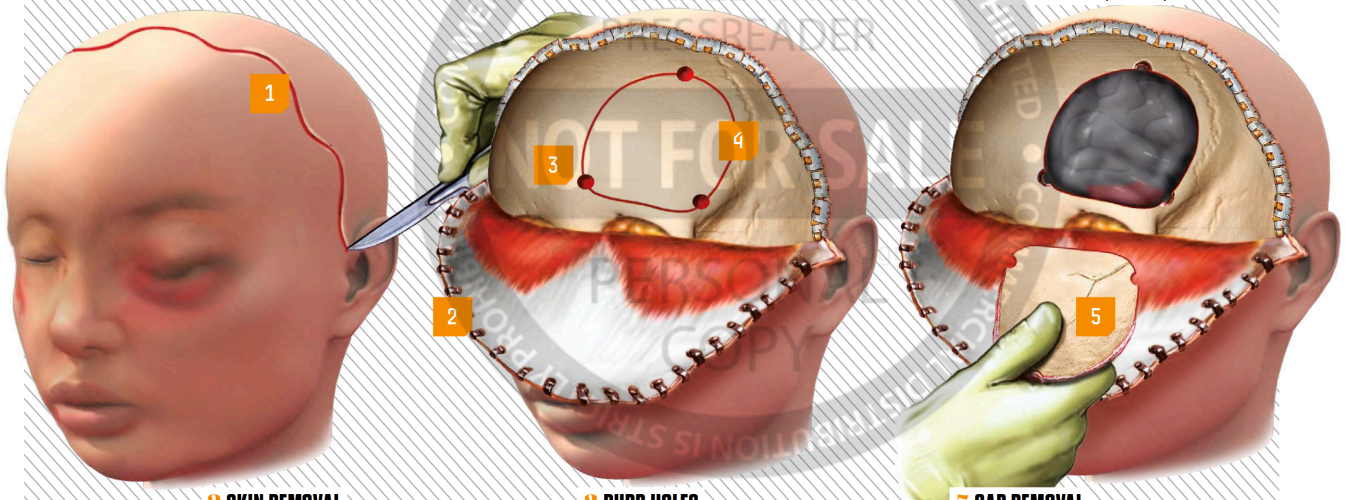
Did you know?
The world's largest brain tumour weighed 1.8 kilograms


The exposed skull of a patient in the midst of a craniotomy

"Brain surgery can be carried out while the patient is awake"

HOLE IN THE HEAD

How surgeons safety gain access to a patient's brain through the skull



1 SHAVED PATCH
A portion of the head is shaved to reveal the site of the surgery.

2 SKIN REMOVAL
The skin is peeled away from the skull and clipped into place.

3 BURR HOLES
Burr holes are drilled into the skull as access points for a surgical saw.

4 CUTTING THE SKULL
A surgical saw connects each of the burr holes to release a piece of the skull, often referred to as a skull cap or flap.

5 CAP REMOVAL
The skull cap is removed, exposing a thin membrane called the dura and the brain.

DID YOU KNOW? Every year, 12,000 people in the UK are diagnosed with a primary brain tumour



A patient receiving laser interstitial thermal therapy

LASER TREATMENT

Laser interstitial thermal therapy (LiTT), also known as laser ablation surgery, uses a magnetic resonance imaging-guided laser to target abnormal cells and tumours to destroy them. During the procedure, a probe is inserted into the brain through a small incision in the head. At the tip of the probe are fibres that are heated up by a laser beam that moves through the probe. The heat is then used to damage any abnormal tissue in the brain. Along with guiding the probe, magnetic resonance imaging is used to monitor the temperature at the tip to ensure that the surrounding healthy tissue remains unharmed.



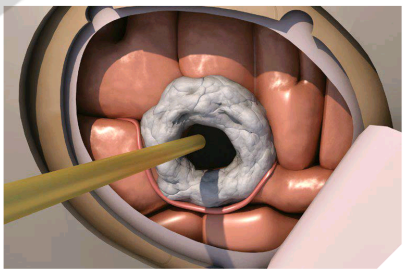
A patient undergoing endoscopic brain surgery

very fast and exciting". One of these emerging fields is the use of robotics during surgery. Since the 1980s, robots have been a helpful feature in the operating theatre. Early innovations, such as the first surgical robot, PUMA 560, have assisted in guiding needles into the brain for biopsy procedures. Today, robots can help surgeons tackle tumours, place brain stents, treat epilepsy and much more.

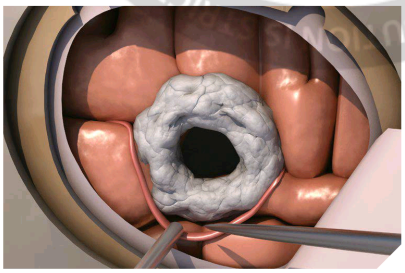
Similarly, the invention of augmented and virtual reality can help surgeons get a better picture of what's going on beneath the skull. "Mixed reality is also being used for visualisation and planning, allowing us to see and project the location of the tumour in virtual reality. These technologies contribute to meticulous planning and promote the use of minimally invasive techniques," says D'Urso.

TUMOUR TAKEDOWN

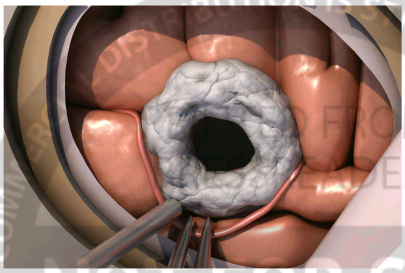
How a surgeon carefully trims away malignant masses and benign tumours



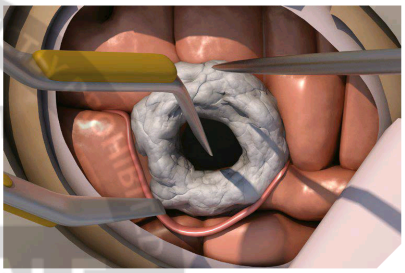
1 INNER REMOVAL
An ultrasonic aspirator, which uses high-frequency vibrations to remove tissue, is used to break down some of the mass of the tumour.



2 TRIMMING
The borders of the tumour are carefully cut away from the surrounding healthy brain tissue.



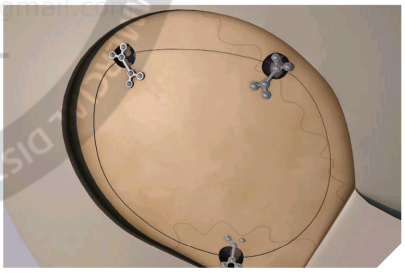
3 SUCTION
While separating and resecting the tumour, any fluid or blood is sucked up through tubes called cannulas.



4 REMOVAL
If possible, the separated tumour can be completely resected and lifted out of the brain.



5 CLOSING UP
The dura flap is closed and stitched back together with sutures or sealant.



6 CAP REPLACEMENT
The original skull cap is replaced and affixed with small metal screws, and the skin flap is put back into place.

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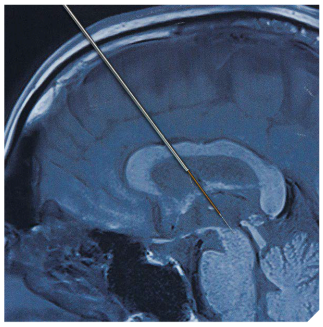
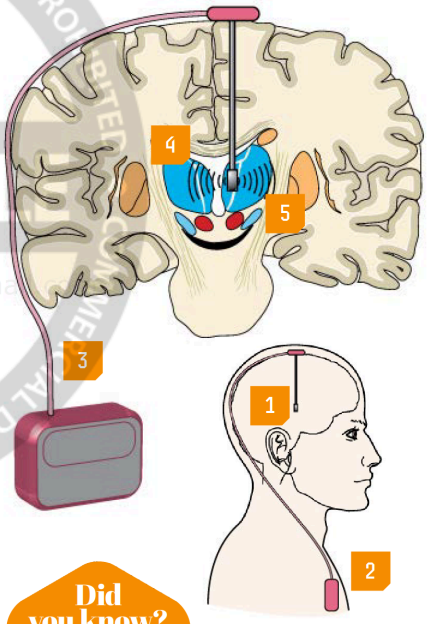
DEEP BRAIN STIMULATION

More than 160,000 people around the world have undergone a procedure that involves inserting a long wire with electrodes at its tip into the centre of the brain. Known as deep brain stimulation (DBS), the surgery is designed to tackle several neurological conditions such as Parkinson's disease and epilepsy. Conditions such as Parkinson's are derived from the disorganisation of electrical signals between neuron cells in the part of the brain designated to movement. DBS can help correct irregular signals and improve the conditions' physical symptoms, such as tremors, by delivering high-frequency stimulation from an electrode inserted into the brain.

To insert the DBS electrode, a surgeon will use imaging technology such as computed tomography to guide the electrode to the target. Electrical impulses are delivered to the electrode by a pulse generator inserted into the chest. The generator and electrodes are connected via a thin insulated wire or 'lead' under the skin. Doctors will create optimal individual electrical programs for each patient to reduce their symptoms.



An illustration of a probe being inserted into the brain for deep brain stimulation



RUNNING INTERFERENCE

How DBS interrupts the electrical signals in the brain to get it back on track

1 ELECTRODES
Electrodes are inserted through small holes created in the skull.

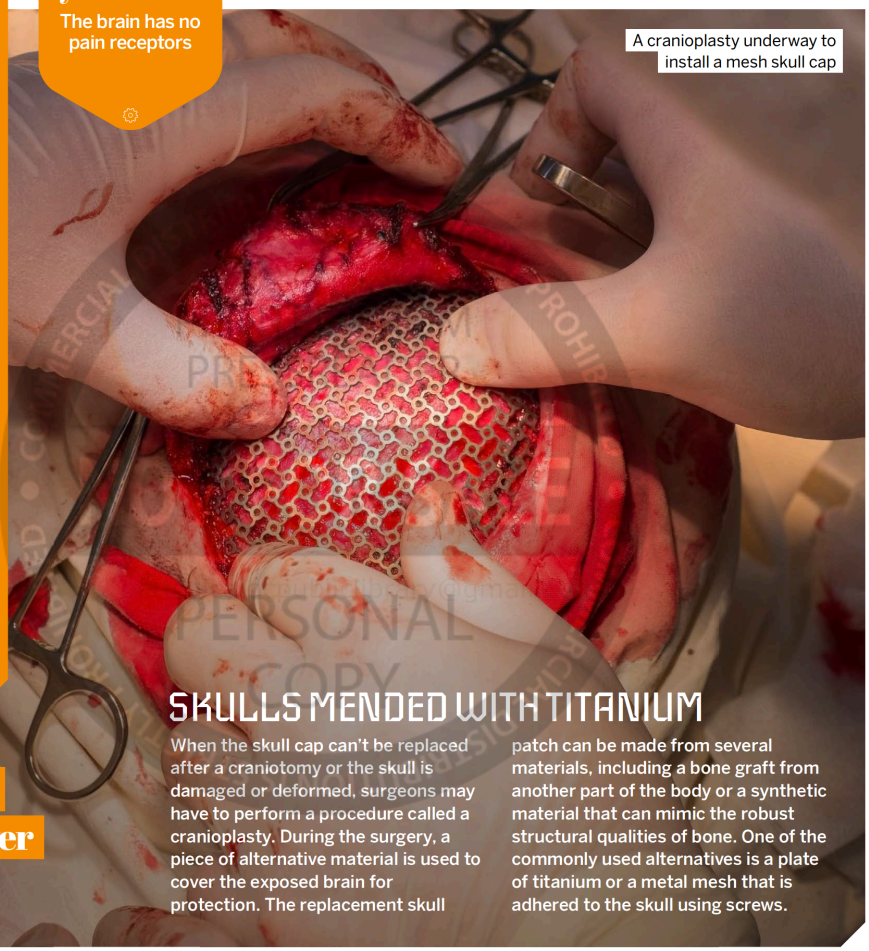
2 GENERATOR
A battery-operated generator is inserted under the skin of the chest.

3 CONNECTION
A wire is threaded under the skin to deliver power to the electrode from the generator.

4 THALAMUS
Electrodes can be placed in the brain's relay station, called the thalamus, to reduce tremors.

5 SUBTHALAMIC NUCLEUS AND GLOBUS PALLIDUS
Electrodes are commonly placed in specific regions such as the subthalamic nucleus or globus pallidus to treat Parkinson's disease.

Did you know?
The brain has no pain receptors



A cranioplasty underway to install a mesh skull cap

"A piece of alternative material is used to cover the exposed brain"

SKULLS MENDED WITH TITANIUM

When the skull cap can't be replaced after a craniotomy or the skull is damaged or deformed, surgeons may have to perform a procedure called a cranioplasty. During the surgery, a piece of alternative material is used to cover the exposed brain for protection. The replacement skull patch can be made from several materials, including a bone graft from another part of the body or a synthetic material that can mimic the robust structural qualities of bone. One of the commonly used alternatives is a plate of titanium or a metal mesh that is adhered to the skull using screws.