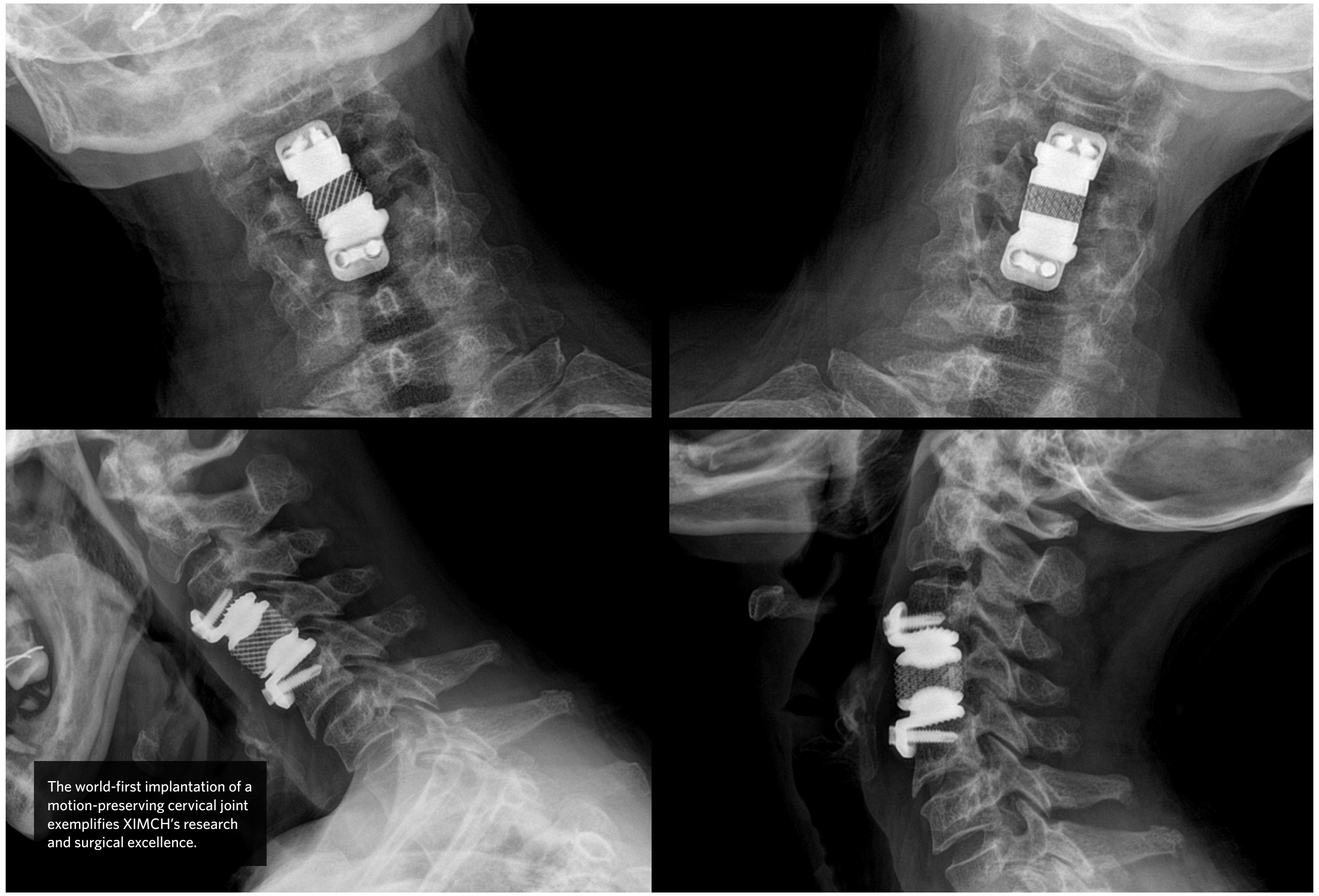
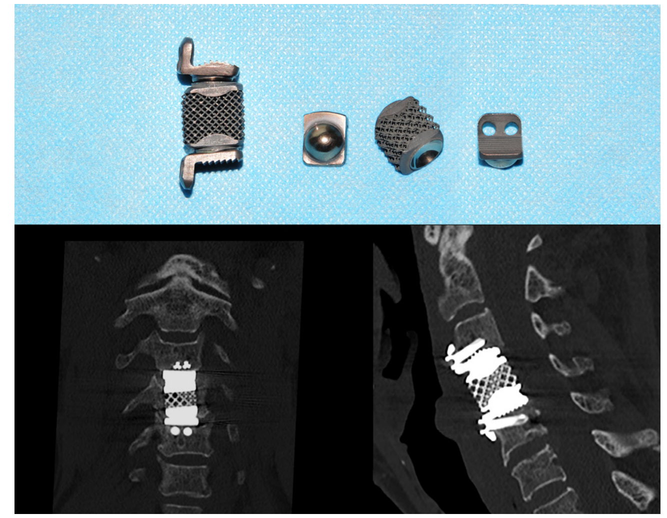
Leading the way on joint implants

Pioneers of cervical implants at Xi'an International Medical Center Hospital (XIMCH) in Western China reveal new directions for CROSS-DISCIPLINARY RESEARCH.



The world-first implantation of a motion-preserving cervical joint exemplifies XIMCH's research and surgical excellence.



XIMCH's world-class facilities target some of the dieases that are most difficult to treat.

Xijing He, president of North Campus of Xi'an International Medical Center Hospital (XIMCH), has led the design of more than three generations of cervical spine implants since 2006, working at the Second Affiliated Hospital of Xi'an Jiaotong University, in collaboration with mechanical engineers and materials scientists at Xi'an Jiaotong University (XJTU).

The team contributed to the world's first reported successful implantion of a motion-preserving cervical joint after an operation to remove vertebrae, known as a cervical corpectomy. The neck's proximity to the skull, arteries, trachea and oesophagus means surgical implants must be of the highest structural precision and clinical safety. "The patient had limb paralysis caused by a cervical tumour. Since the surgery, we restored a range of motion and muscle strength, a short-term study showed," says He.

"Our success marks the beginning of a long-term health evaluation of this patient, as well as clinical studies on a larger scale."

He has also obtained patents in China and the United States based on his spinal implants research, work continually shaped by a series of animal and biomechanical experiments.

BIONIC DESIGNS DRIVEN BY PATIENT NEEDS

The cervical spine has seven stacked bones (C1 to C7), with interspersed cushions known as intervertebral discs. One of the leading causes of upper limb pain and paralysis, cervical disc herniation (CDH) is a degenerative disorder caused by a protruding disc which presses against the spinal cord or nerve root. Its incidence increases with age. One of the standard surgical procedures for CDH is anterior cervical corpectomy and fusion (ACCF), in which surgeons remove part of the affected vertebrae. This is followed by a bone graft or insertion of a titanium mesh cage (TMC) to maintain stability.

He's team started out by improving the TMC. "Traditionally manufactured with a fixed length, the TMC has to be cut and adjusted specifically for a patient during surgery, and these manual procedures might leave sharp edges. Furthermore, the cylindrical shape of the TMC, with only its tangential plane in contact with tissues, can lead more easily to dislocation and subsidence," says He.

Advances in 3D printing, including selective laser melting (SLM), has enabled improved TMC design. As well as proposing a square-shaped TMC to expand its contact surface with the surrounding tissues, in a 2017 comparative study, He found that adding rings on both ends of the TMC at an oblique angle provides the highest compressive force to resist subsidence.

Further stability is achieved by introducing a porous scaffold to support new bones, and He has identified a correlation between bone growth and the pore size. His 2020 study on rabbit models used computational fluid dynamics analysis to show how cell proliferation changes with hydromechanical properties, including permeability and flow rate. Among openings from 400 to 1,100 μm, he showed that new bone growth was induced best through a 650 μm pore design, giving the greatest structural security. The work demonstrates the value of combining computational simulation and laboratory experiments.

LONG-TERM PATIENT CARE

Patients having undergone ACCF with the improved TMC still risk losing motion of the cervical joints. "Fusion still takes away the motion of the intervertebral space between the adjacent segment and the resected vertebra. A C4 level operation, for example, often sacrifices the C3-4 and C4-5 spaces," he says.

He designed motion-preserving cervical implants in three parts: a 3D printed artificial vertebra in the middle, which is used to fill the bone defect after resection, in between two ball-and-socket joints with carburized surfaces to improve wear. The bionic structure reduces friction and preserves motion of the vertebral segments, maximizing range of motion in flexion, extension, and lateral bending, while reducing the possibility of dislocation.

He's ongoing research into better elasticity, abrasive resistance and stability also led to advances in bionic bio-ceramics. "Polyether ether ketone (PEEK) is good for reducing the elastic modulus of the implants, but its hydrophobicity can lead to poor bone integration," he says. "We investigated how another compound of the same family, polyether ketone ketone (PEKK), can be combined with aluminium oxide to obtain an elastic modulus closer to human bones with better wear resistance, thereby extending the lifespan of the motion-preserving cervical joint implant."

XIMCH is becoming a world renowned hospital, with first-class infrastructure for surgeries as complex as implantation of motion preserving cervical joint implants. Teams at each specialized department are dedicated to treating the most acute and critical diseases. ■

西安国际医学中心医院
XI'AN INTERNATIONAL MEDICAL CENTER HOSPITAL
Phone: +86-029-88330516
Email: imic@000516.cn
Website: www.imc-xa.cn