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Biomimicking Photocrosslinkable Nanocomposite Bone Graft

All-round injectable and 3D printable bone graft substitute that promotes bone healing

Bone graft has been the gold standard for treating severe bone defects. Artificial bone graft substitutes have emerged, but they are either difficult to shape and mould or unable to carry bioactive compounds that promote bone regeneration. Researchers from the Department of Biomedical Engineering thus developed Biomimicking Photocrosslinkable Nanocomposite Bone Graft, an all-round bone graft substitute that is injectable and 3D printable, mechanically strong, and capable of carrying bioactive molecules, while stimulating bone and blood vessel growth.

Dr Zhao Xin (middle) and her team

Bone fracture is one of the most common traumatic injuries. On average, every person experiences two broken bones throughout one's life[1]. Most cases just entail a cast or a splint, and the broken bone will heal on its own. However, when bones are severely crushed or fractured, a bone graft could be necessary. Natural bone graft has lower risks of cross infection or immunological rejection, but does not provide mechanical strength. Synthetic bone graft substitutes provide support, but can be difficult to mould into desired shapes to fit the bone defect. Those injectable ones often cannot incorporate bioactive compounds. In light of this, Dr Xin Zhao, Associate Professor, Department of Biomedical Engineering, led a research team to develop Biomimicking Photocrosslinkable Nanocomposite Bone Graft, an all-round solution that encompasses the advantages of both natural bone graft and artificial substitutes.

Conventional bone graft

Bone grafting, the transplanting of bone tissue to fix damaged bones, has been practised for over a century. Up till now, it is regarded as the gold standard for filling severe bone defects and voids caused by diseases or injury. Bones can be harvested from the patients themselves or bone banks, and transplanted to the site of bone defects. The harvested bone is ground into a paste and injected to fill the bone voids or fractures, as "seeds" to induce the regeneration of the patient's own bone cells.

3D-printed biomimicking photocrosslinkable nanocomposite bone graft

Biomimicking photocrosslinkable nanocomposite bone graft is 3D printable and injectable.

"On the upside, the risk of rejection for conventional bone graft is rather low. On the downside, in the case of using patient's own bone, he/she may suffer from pain or discomfort at the site where the bone tissue is collected," said Dr Zhao. The bone paste used for the procedure also provides no mechanical support, so that the patient is confined to bed for a prolonged period after the surgery, retarding recovery. "Recent research shows that weight-bearing exercise is essential for bone healing after a patient receives orthopaedic surgery. Using bone graft substitutes that provide adequate support means the surgical site can accept stress load almost immediately after the surgery, promoting bone growth."

Artificial bone graft substitutes

In recent years, artificial bone graft substitutes have attracted much interest. According to Dr Zhao, though some of them provide good mechanical support, they could be difficult to mould or machine into the right shape to fit a surgical site. Injectable synthetic bone graft materials can be shaped easily, but they often need high heat to harden or contain organic solvents. That means bioactive molecules, such as growth factors, which promote bone cell regeneration and metabolism cannot be incorporated in them, as they are readily destroyed by high heat and organic solvents. She explained, "That's why our team has been working on an all-round artificial bone graft substitute that has all the advantages of natural and synthetic bone grafts, yet without their shortcomings."

Biomimicking Photocrosslinkable Nanocomposite Bone Graft

The groundbreaking bone graft that Dr Zhao and her team developed is a monomer-based thick paste that mimics the structure of human bone with no risk of immunological rejection. It can either be pre-made into engineered porous scaffolds with a 3D printer and trimmed to fit a surgical site, or injected and applied directly during surgery. When the material is exposed to ultraviolet rays at 36°C for 140 seconds, it sets and acquires mechanical strength instantly so that stress load can be applied to the surgical site soon afterwards. It also encourages bone cell and blood vessel regeneration, thereby speeding up recovery further. As the material does not need high heat to set and contains no organic solvents, it can preserve bioactive molecules like growth factors and release them in a sustained manner. All in all, this new bone graft substitute manages to speed up bone healing in major ways.

In March 2021, Biomimicking Photocrosslinkable Nanocomposite Bone Graft won a silver medal at the Special Edition 2021 Inventions Geneva Evaluation Days - Virtual Event, an online version of the prestigious International Exhibition of Inventions of Geneva.

[1] *Retrieved from https://www.osteo-pharma.com/bone-fracture-facts/*