PolyU Develops Novel Self-fitting Scaffold for Bone Regeneration

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HONG KONG (PRWEB) August 14, 2018 -- Researchers from The Hong Kong Polytechnic University (PolyU) have designed and fabricated a high performing self-fitting bone scaffold by combining a shape memory foam and hydroxyapatite (the principal mineral component of bone tissue). It can be safely and conveniently implanted into bone defects and induce bone regeneration, thus enhancing the recovery of bone injuries and fractures. Up to date, no bone scaffold in commercial market possesses such shape memory self-fitting effect.

Despite the regenerative capacity of bone, for large bone defects due to bone tumor resections or severe fractures, bone grafting surgeries (autografts or allografts) are always required for orchestrating bone regeneration. With bone fracture becoming a rising worldwide health concern, especially for ageing societies, how to improve grafting process or induce bone regeneration effectively, thus help relieve suffering and reduce society’s medical expenses, have become a rising challenge for scientists. Taking hip fractures from osteoporosis as an example, a latest study projected that the number of annual new cases in Hong Kong, of 9,590 this year, will be tripled by 2050; while Malaysia and Singapore will reach 3.5 times during the period.

One promising field explored by tissue engineering scientists is to develop a bone scaffold which can act as template for speedy tissue regeneration, and can be used in minimally invasive operation so as to reduce hospitalization stay and infection risk. The novel scaffold developed by the team of PolyU researchers, led by Professor Hu Jinlian (Principal Investigator) and Dr Xie Ruiqi from the Institute of Textiles and Clothing, and Dr Guo Xia from the Department of Rehabilitation Sciences, has offered promising breakthrough. The team has close collaboration with Sichuan University in cell culture and animal modelling for the research.

Characteristics of PolyU’s novel bone scaffold

The novel scaffold made of shape memory polyurethane foam (a type of plastic material) and hydroxyapatite (HA) nano-particles is characterized by its remarkable self-fitting effect. As a shape memory material, the scaffold can be compacted at 0°C, implanted with compact shape at room temperature, and recovered to its original shape completely at 40°C. The scaffold thus can fill up the irregular bone defects perfectly. The transitional temperatures, with range close to human body’s physiological temperatures, also enhance the feasibility of using the scaffold in minimally invasive surgery.

The self-fitting scaffold possesses a highly porous structure with interconnected pores to allow cells migration and formation of new tissues. The average pore size of the scaffold is 670 μm (diameter of a human hair is around 100 μm), which is close to that of trabecular bone (the inner layer of bone) and thus mimics the actual in vivo microenvironment. The optimal structure of the scaffold is around 60% of space voids.

The mechanical strength of the scaffold can neither be too low (may cause deformation or crash) nor too high (may reduce the density of surrounding bone tissue). The compressive strength of the PolyU developed self-fitting scaffold is designed at 13.6MPa (Megapascal), which is comparable to that of trabecular bone. Laboratory tests also show that the self-fitting scaffold is biocompatible and has no cytotoxicity.
Animal study on bone regeneration

“Our research team further examined the performance of the self-fitting scaffold in facilitating bone regeneration through a rabbit femoral defect study. The results show that our scaffold has overcome the disadvantages of traditional polymer scaffolds, and has great potential for bone regeneration,” said Professor Hu.

In the animal study, 18 rabbits with a femoral bone defect in each knee, making up a total of 36 lesions, were divided into experimental group and control group.

The bone defects of the rabbits in the experimental group were implanted with self-fitting scaffolds (with original size around 5% larger than the bone defects) compacted to around 50% of their original size. After triggering with 40°C saline, the scaffolds expanded from the compacted shape to fill the defect in 60 seconds. The bone defects in the control group were left unfilled.

Twelve weeks after the surgery, the experimental group displayed faster bone tissue ingrowth in volume. There was 46% of bone ingrowth, or the proportion of total defects being repaired. On the contrary, the control group had only 24%.

The self-fitting scaffold has been proved inducing the formation of osteoblasts and blood vessels, which are responsible for the synthesis of bone tissue. In the experimental group, 12 weeks after the surgery, the number of neovascular buds grew on the scaffolds was 4 times of that in the control group. Moreover, 5% of bone surface was covered by osteoblasts in the experimental group whereas the control group recorded almost no osteoblast.

In conclusion, the novel shape memory scaffold developed by PolyU has the advantages of:
- being implanted via minimally invasive operation;
- self-adaption and self-fitting;
- optimal structure for bone remodeling;
- full biocompatibility; and
- optimal mechanical properties.
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