

# How metal scaffolds enhance the bone healing process

January 22 2018

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Over the course of 24 weeks, new bone tissue developed, filling the titanium scaffold's honeycomb-like structure. Both types of scaffold are depicted here. Credit: Julius Wolff Institut/Charité

A new study shows how mechanically optimized constructs known as titanium-mesh scaffolds can optimize bone regeneration. The induction of bone regeneration is of importance when treating large bone defects. As demonstrated in this preclinical study, both the speed and effectiveness of the process depend upon the stiffness of the implant used, with softer constructs enhancing the healing process. The findings have been reported in the current issue of *Science Translational Medicine*.

The treatment of large [bone](#) defects in the upper or lower extremities (for instance, as the result of acute trauma, infection or [bone cancer](#)) remains a challenge in the field of trauma surgery. Bone defects of this kind do not heal on their own, and in particularly severe cases, will result in amputation of the affected limb. One treatment option is to use the patient's own bone tissue to produce [bone grafts](#) of the correct size and strength. However, this technique has been of limited success. An alternative treatment option, offered by Charité's Center for Musculoskeletal Surgery, is to treat large bone defects using individualized titanium-mesh scaffolds designed to fit the individual patient.

This technique uses CT scan data to produce a 3-D model of the affected bone and the bone defect. Using a 3-D printer with laser sintering technology, these data are then used to manufacture a titanium scaffold to patient-specific requirements. The customized structure is surgically implanted into the affected bone. Results of this procedure are promising, with a total of 19 patients at Charité having so far been treated using this type of implant.

To promote [bone regeneration](#), the titanium-mesh scaffold is filled with the patient's own [bone tissue](#), growth factors, and bone replacement material. Led by Dr. Anne-Marie Pobloth (Julius Wolff Institute at Charité), an interdisciplinary team of trauma surgeons, engineers, veterinary surgeons and biologists has studied whether mechanical optimization of the titanium-mesh scaffold might enhance the healing process. "We started by using computer modeling to mechanobiologically optimize a standard-size scaffold. Using a large animal model, we were then able to study its actual effects on bone regeneration. As the process of bone regeneration is very similar to that found in humans, we were able to make inferences regarding [bone healing](#) in humans," explains the veterinarian.

The optimized scaffold has a honeycomb-like structure aligned to form channels that guide the ingrowth of bone. By altering the strut diameter of the honeycomb, the researchers produced structures of varying stiffness. "We assumed that bone regrowth would vary according to the stiffness of the implanted scaffold. Therefore, in order to study the effects of mechanical stimulation during the bone regeneration process, we used four test groups receiving implants of varying stiffness," explains Prof. Dr. Georg N. Duda.

Trauma surgeon Dr. Philipp Schwabe says, "After only three months, radiographic evidence showed that soft implants produced faster bone growth in response to increased mechanical stimulation than stiffer implants." The biomechanical properties of the implant affected both the quantity and quality of newly formed bone, as well as on the type of [bone formation](#) produced within the [scaffold](#).

The team plans to produce mechanobiologically optimized, softer titanium-mesh scaffolds, ensuring patients can benefit from their findings and making it easier to treat bone defects. Rather than being restricted to use with the long bones of the arms and legs, it is also conceivable that this method may be able to be used in spinal, oral and maxillofacial surgery.

**More information:** Anne-Marie Pobloth et al, Mechanobiologically optimized 3D titanium-mesh scaffolds enhance bone regeneration in critical segmental defects in sheep, *Science Translational Medicine* (2018). [DOI: 10.1126/scitranslmed.aam8828](https://doi.org/10.1126/scitranslmed.aam8828)

Provided by Charité - Universitätsmedizin Berlin

Citation: How metal scaffolds enhance the bone healing process (2018, January 22) retrieved 24

April 2024 from <https://medicalxpress.com/news/2018-01-metal-scaffolds-bone.html>

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