McGowan Institute for Regenerative Medicine
A program of the University of Pittsburgh and UPMC

Bioresorbable Metals in Regenerative Medicine

Researchers from the University of Pittsburgh's Swanson School of Engineering and the McGowan Institute for Regenerative Medicine are creating biodegradable tissue repair structures for the human body as well as developing degradable magnesium (Mg) alloys for craniofacial and orthopedic applications.

McGowan Institute for Regenerative Medicine affiliated faculty member Prashant Kumta, PhD, the Swanson School's Edward R. Weidlein Chair Professor and professor of bioengineering, chemical and petroleum engineering, mechanical engineering and materials science, and professor of oral biology in the School of Dental Medicine, is the principal investigator of the America Makes project entitled "Additive Manufacturing of Biomedical Devices from Bioresorbable Metallic Alloys for Medical Applications." Dr. Kumta was recently interviewed by Bridget Butler Millsaps of *3DPrint.com* about how his lab is using 3D printing to produce microscopic scaffolds of iron (Fe) and manganese (Mn) alloys to foster new bone and tissue growth.

Using a Fe-Mn combination, Dr. Kumta has discovered a 3D printed material that corrodes more effectively and rapidly. It has also been verified as a viable solution in pre-clinical studies due to a 3D printed mandible researchers were able to produce working from a CT scan. The research study is promising because it shows that indeed these scaffolds are significantly similar to those of bone and allow for good "cell viability" as well as "cell infiltration."

"What makes our materials unique is that we are printing novel proprietary alloys that are biodegradable," Dr. Kumta told *3DPrint.com*.

With metals offering greater durability and success than plastics or polymers for artificial scaffolding, this has led researchers to give attention to attempting its use in 3D printing and use for tissue regeneration. With the Fe-Mn combination, all the required elements come together for density, mechanical properties, as well as the required porous qualities for widespread tissue formation.

"The proprietary Fe based alloys that have already been printed by our binder jetting printing approach is unique and demonstrates faster and improved degradation," Dr. Kumta said. "Similarly, we are showing demonstration of ability to print novel proprietary Mg based alloys also by the binder jetting printing approach… Both of these examples of novel alloys fabricated into 3-D constructs using our Additive Manufacturing approach are unique."

As published recently in *Acta Bacterialia*—by authors Dr. Kumta and McGowan Institute for Regenerative Medicine affiliated faculty members Konstantinos Verdelis, DDS, PhD, assistant professor of restorative dentistry/comprehensive care, School of Dental Medicine, Bernard J. Costello, MD, DMD, professor, chief/division of craniofacial and cleft surgery, and Charles Sfeir, DDS, PhD, associate dean of research in the School of Dental Medicine, an associate professor in the Clinical and Translational Science Institute, an associate professor in the Schools of Dental Medicine and Engineering, and the founding director of the Center for Craniofacial Regeneration—each year millions of Americans suffer bone fractures, often requiring internal fixation. Current devices, like plates and screws, are made with permanent metals or resorbable polymers. Permanent metals provide strength and biocompatibility, but cause long-term complications and may require removal. Resorbable polymers reduce long-term complications, but are unsuitable for many load-bearing applications. To mitigate complications, degradable Mg alloys are being developed for craniofacial and orthopedic applications. Their combination of strength and degradation make them ideal for bone fixation.

In accordance with the team's pre-clinical study, they observed bone formation surrounding 99.9% Mg devices in an ulna fracture model, with fracture healing by 8 weeks and complete overgrowth by 16 weeks. Device degradation, fracture healing, and bone formation were evaluated using microcomputed tomography, histology, and biomechanical tests. Bend tests revealed no difference in flexural load of healed ulnae with Mg devices compared to intact ulnae. These data suggest that Mg devices provide stabilization to facilitate healing, while degrading and stimulating new bone formation.

Illustration: Wikipedia.

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Abstract (In vivo study of magnesium plate and screw degradation and bone fracture healing. Chaya A, Yoshizawa S, Verdelis K, Myers N, Costello BJ, Chou DT, Pal S, Maiti S, Kumta PN, Sfeir C. Acta Biomaterialia; 2015 May;18:262-269.)

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