UNC CHARLOTTE

Bioceramic Material Used in Regenerating Bone

When implanted in the body, the patented bioceramic material invented by Dr. Ahmed El-Ghannam assists and accelerates the creation of new bone. In his research into applications for the material, Dr. El-Ghannam is developing variations and techniques for fast regenerative healing, structural bone repair and orthopedic implant coatings.

Dr. El-Ghannam is an associate professor of Mechanical Engineering and Engineering Science in the Lee College of Engineering and a researcher in the UNC Charlotte Center for Biomedical Engineering Systems. His patented bone implant material is a silica and calcium phosphate composite. Classified as a bio-active material, the composite enhances and stimulates cell function, which in turn enhances tissue and bone growth.

"Both silica and calcium are essential for bone metabolism and bone growth," Dr. El-Ghannam said. "Sixty-five percent of our bone is calcium phosphate. Silica is found in much smaller amounts, but it is absolutely essential for metabolic reaction and bone growth."

When implanted in the body next to actual bone, the bioceramic material stimulates bone cell function. The bone cells attach to the material and absorb its calcium, using it as a food for reproducing real bone tissue. Over time, the volume of new bone increases and that of the bioceramic decreases.

Dr. El-Ghannam has developed a porous version of the material that stimulates the regeneration of bone at a rapid rate. The porous bioceramic material can be used to treat injuries and diseases in bone that does not carry large structural loads.

For injured bone that does carry a greater load, Dr. El-Ghannam has developed a denser bioceramic material. It is stronger than the porous version, but does not regenerate to bone as quickly. The denser version can be used as bone replacement or as orthopedic fixation devices such as plates and screws.

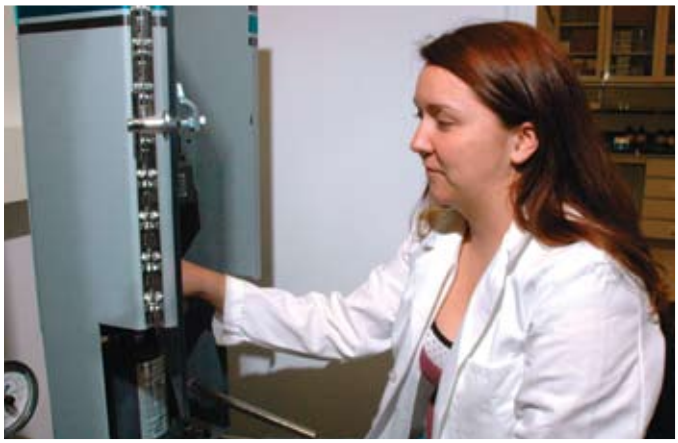
"The material has a great advantage over using metal, in that it does not introduce foreign material into the body," Dr. El-Ghannam said. "It doesn't have the side effects of metal, which because of its high mechanical properties often takes on too much load. When the metal takes too much load, the bone gets weakened."

When using the material to replace a segment of damaged bone, researchers first do a scan to determine exact dimensions for the replacement part. These dimensions are programmed into a rapid prototype machine, which creates an exact replica of the bone using the bioceramic powder.

Another application of the new bioceramic material is the coating of orthopedic implants such as artificial hips and knees. An existing problem with implants is that cells do not physically bond to it, and over time activity causes loosening of the implant, which leads to severe pain and implant failure.

"By adding a 20-25 micrometer bioceramic coating to the metal surfaces of the implant," Dr. El-Ghannam said, "the existing bone and tissue will bond to the material, forming a much stronger connection. The implant will be better anchored to the bone, and there will be less play and motion to weaken the bone."

Coating metal with the bioceramic is complicated, because the thermal expansion of the ceramic is different from that of the metal. An electrochemical process is used, in which the ceramic is suspended in alcohol and electrical current is run through it. The metal is then placed into the mixture, and the ceramic molecules bond to the metal. The final step is a heat treatment at a specific rate and temperature, which strengthens the adhesive bond without harming the metal.



photos
above - Dr. Ahmed El-Ghannam with a sample of his patented bioceramic material.
- A section of artificial jaw bone made by scanning existing bone and then using a rapid prototype machine to make an exact replica out of bioceramic powder.

photos
right - Master's student Amy Sparnell prepares a high-density bioceramic mixture, from which orthopedic screws will be milled. By making bone fixation devices out of bioceramic material instead of metal, bone healing is improved and further surgeries to later remove metal are eliminated.

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