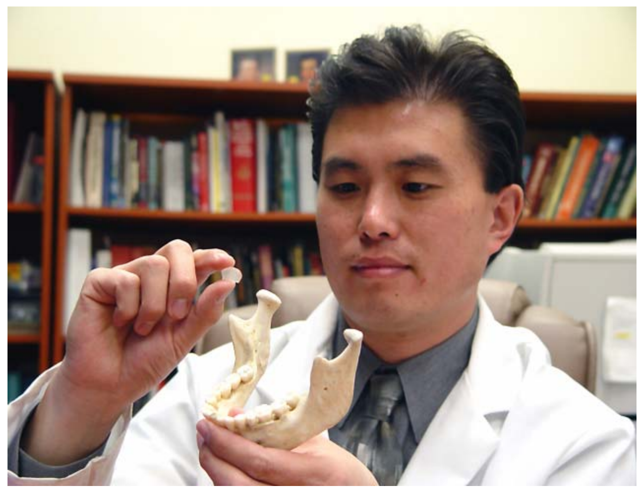
Designer Bones

In the future, a patient in need of a new bone or bone section may be able to have one made using a mold, a gel solution, and a few drops of adult mesenchymal stem cells (MSCs). These versatile precursor cells, found in bone marrow and fat tissue, can transform into different cell types, including bone, cartilage, and skeletal muscle. Using adult MSCs taken from leg bones of rats, scientists have fashioned a human-shaped mandibular condyle – the rounded protrusion on each side of the lower jawbone, or mandible, that forms a ball-and-socket joint with the bottom of the skull. Using similar procedures and a patient's own stem cells, clinicians might eventually be able to build an entirely new jaw, knee, or hip for someone who has lost these structures to disease or injury.

Making Bones From Cells

To produce the mandibular condyle, Dr. Jeremy Mao, associate professor of bioengineering and orthodontics at the University of Illinois at Chicago, and his colleagues established two cultures of rat MSCs. The researchers treated one culture with a growth factor that transformed the MSCs into chondroblast cells, which form cartilage. The other culture was treated with a chemical mixture that transformed the cells into osteoblast cells, which form bone. Each cell type was then mixed with a nontoxic liquid gel and a jelling compound that responds to ultraviolet (UV) light.

Next, the researchers poured the chondroblast solution into the bottom layer of plastic molds shaped like human mandibular condyles and exposed the solution to UV light, causing it to solidify. The molds were then topped with osteoblast solution, which also solidified under UV light. The resulting condyle-shaped objects, each about the size of a child's marble, were placed under the skin of immunodeficient mice for up to three months, where the implants absorbed nutrients from the surrounding fluids.



Dr. Jeremy Mao compares the tissue-engineered mandibular condyle (left) with the condyle on a human mandible, or lower jawbone.
Photo courtesy of University of Illinois at Chicago

Later examination of the implants suggested that the osteoblasts and chondroblasts had begun producing normal bone and cartilage tissue, respectively. Staining the tissues for bone and cartilage components and examining slices under the microscope showed that the tissues looked similar to natural bone and cartilage. Moreover, each cell type expressed genes and produced chemicals characteristic of its tissue, and the calcium content of the bone tissue increased normally over time. However, despite similarities to normal bone and cartilage, the engineered condyles were not strong enough to replace condyles in human patients, says Dr. Mao. "Right now, the tissue-engineered condyles are about as strong as those found in newborn babies," he says.

Adding Strength

The researchers are now trying two approaches to increase the mechanical strength of the condyles. One approach is to administer chemical growth factors encapsulated within slow-release microspheres to the cells in the condyle. "After the UV light solidifies the gel, the growth factors are released from the microspheres over a period of several weeks, promoting further tissue growth and maturation," says Dr. Mao.

The other approach is to apply mechanical stresses to cells at various points in producing the condyle. "We plan to mechanically stress the stem cells while they are still in cell culture and then later mechanically stress the osteoblasts and chondroblasts located within the gel," says Dr. Mao. "These treatments may increase the rate of tissue formation and strengthen the extracellular matrix between the cells."

“One day, a person who has lost a joint to arthritis may be able to walk into a clinic, and clinicians will do liposuction to get some stem cells from the fat tissue and with those make the person a new joint,” says Dr. Mao.

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References

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