Next generation bone regeneration by medicine-engineering cooperation and its clinical application

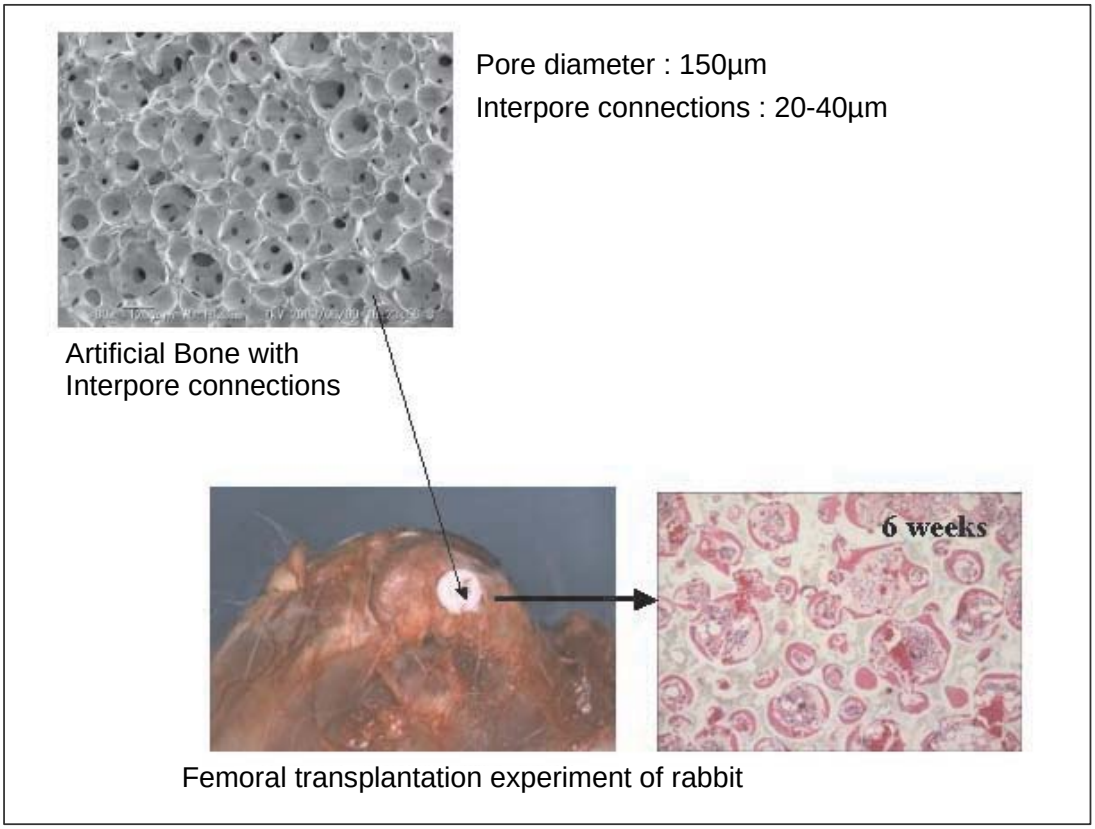
Bone regeneration , Cartilage regeneration , Osteogenetic factors , Artificial bone , Bone marrow cells

Representative researcher : Hideki Yoshikawa (professor)
Organ control surgery, Organ Control Medicine, Department of Medical Research

1 Bone regeneration using artificial bone hybridized with bone marrow stem cells

For bone tissue regeneration, biomaterial serving as a good scaffold and osteoblasts with osteogenicity are necessary. In this study, novel hydroxyapatite with a continuous pore structure with properties physically and biologically equivalent to those of bone in the body will be developed by applying the technique of forming ceramics with completely continuous pores using a foaming agent. This novel hydroxyapatite will be hybridized with osteogenic cells, such as auto-bone marrow cells and differentiation-inducing proteins such as osteogenetic factors or their genes to develop artificial bone with biological activity capable of complementing bone defect with a specific size in a specific region.

Artificial bone with a shape corresponding to bone defects will be prepared by morphological simulation technique using a computer. For a large bone defect, the hydroxyapatite will be implanted with vascular tissues in muscle tissue in vivo to prepare artificial bone with nutrient blood vessels transplantable for a specific region.



Femoral transplantation experiment of rabbit

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2 Regeneration of articular cartilage using synovial membrane-derived mesenchymal cells

For regeneration and repair of articular cartilage, auto-chondrocytes and bone marrow stem cells have been used, but good therapeutic results have not been obtained. In this study, we will develop batch culture technique of synovial cells and technique of preparing 3-dimentional synovial cell-matrix complex with size and shape corresponding to therapeutic uses.

Since the complex matrix can be constructed into various shapes and has sufficient physical strength, its surgical manipulation is easy. Since matrices contain abundant cell adhesion factors such as collagen and fibronectin, the complex and the recipient tissue are biologically connected within a short time.

Using this 3-dimensional synovial cell-matrix complex, we will attempt clinical regeneration of articular cartilage for cartilage injury and degenerated cartilage in osteoarthritis after animal studies in rabbits and pigs at the Medical Center for Translational Research of the Hospital of Osaka University School of Medicine.

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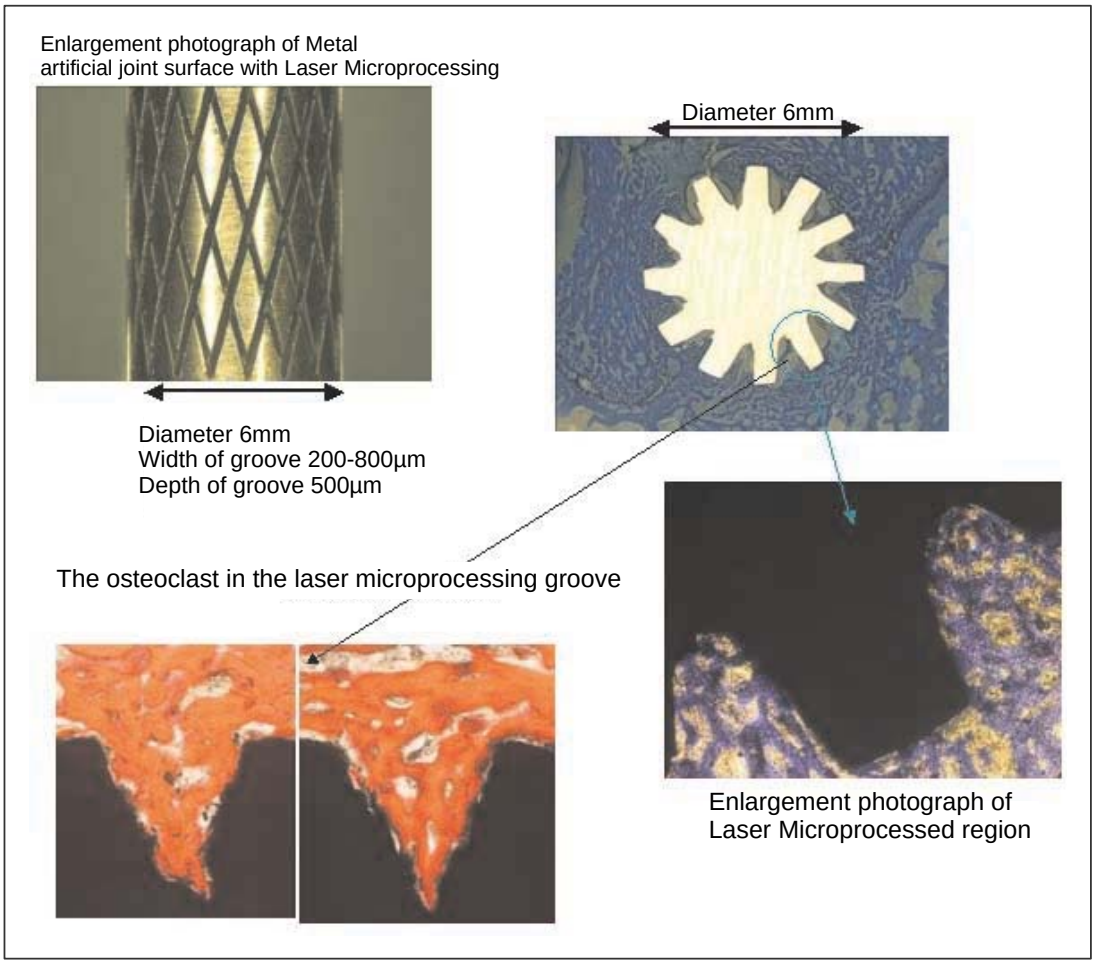
3 Development of novel artificial joint with laser surface processing

The most serious problem with current artificial joints is loosening of metal inserted in bone with long-term use, which has been considered as useful life of artificial joints. Compatibility and immobilization between the metal surface and bone are considered to be the most important causes. To prepare uneven artificial joint surface and promote entrance of osteocytes into joint to increase compatibility and close adherence, welding of metal particles sprayed on the surface and mechanical processing for formation of uneven surface have been investigated. However, control of the shape of unevenness was not possible, causing problems such as insufficient compatibility and immobilization of the metal surface with bone, and insufficient strength of the welded metal surface.
Using precise processing technique using laser for ultra-hard materials developed by the Department of Engineering Research, this study will achieve precise groove processing of the surface that most markedly promotes surface invasion by osteocytes and bone regeneration without changing the strength of the artificial joint, and develop revolutionary artificial joint. This study will develop artificial joints in which no loosening occurs, using the above new metal surface processing technique for artificial joints, which has not previously reported.



Other study contents of Yoshikawa laboratory

- Rheumatoid arthritis therapy for using NFkB decoy nucleic acid pharmaceuticals
- Development of a new diagnostic method of bone soft tissue tumors using gene analysis
- Analysis of postoperative dynamics of artificial joint using 3-dimensional CT and MRI
- Development of a robotic surgical method of artificial joint