Stem Cells and Tissue Engineering For Bone and Joint Repair, Restore, Regenerate, and Replace

Prof. Ismail Hadisoebroto Dilogo, MD, Ph.D[1,2,3]

[1]Head of Stem Cell and Tissue Engineering Research Center IMERI Faculty of Medicine Universitas Indonesia, Jakarta, Indonesia
[2]Head of Stem Cell Integrated Service Unit Cipto Mangunkusumo Hospital, Jakarta, Indonesia
[3]Professor Orthopaedic and Traumatology Department Cipto Mangunkusumo Hospital, Faculty of Medicine Universitas Indonesia, Jakarta, Indonesia

Abstract

Nowadays, the application of stem cells in the medical field is on the rise, as shown by the number of clinical trials in the world with 1460 studies that have been finished or are still in the research stage. The most categories are musculoskeletal diseases followed by neurological diseases, covid-19 related diseases, and trauma. Therefore, stem cell research is currently highly linked to therapeutic developments in orthopaedics and traumatology. Stem cells themselves have several functions in regenerative medicine. These cells work by tissue engineering by replacing structures in certain locations of the human body, such as cartilage, bone, tendon, skin, muscle, nerves, liver, pancreas, and several other target organs. Besides tissue engineering, stem cells could work for replacing metabolism with cell-based therapy.

Tissue engineering has three major components: Biomaterials, Regulatory Signals, and Cells. The biomaterials, such as ceramics and synthetic polymers, will facilitate growth factor delivery by inducing regulatory signals. Regulatory signals, such as growth factor and mechanical stimulus will induce cell differentiation and tissue formation. The cells that have been induced will attach and migrate into the scaffold which supports cell growth, proliferation, and matrix deposition. Therefore, those three components are referred to as the tissue engineering triad.

In the diamond concept of bone healing, osteogenic cells, osteoinductive mediators, osteoinductive matrix, and mechanical stability. Mesenchymal stem cells (MSCs) can be used as an osteogenic agent in connection with the diamond concept. These cells can regenerate the affected bone tissue by differentiating into other cells, including bone cells. It was anticipated that after implantation, the cells would colonize and develop along the correct MSC lineage at the lesion site. Cytokines, chemokines, growth factors, and other chemicals that have been produced will get beneficial effects on wounded tissues by boosting angiogenesis and reducing fibrosis, death, and inflammation. In our previous translational study using a combination of Hydroxyapatite granules, allogenic human Umbilical Cord-MSCs (hUC-MSCs), and BMP-2 in two-stage masquelet procedure for critical-sized bone defects showed the increasing LEFS after the end of the follow-up period, showing the improvement of functional ability.

In the several studies that have been conducted on the usage of hUC-MSCs in patients with knee OA, MSCs have shown that has some potential as regenerative medicine therapy. In conjunction with the several studies before, we already conducted a single-arm study that included 57 knees implanted with 10×10^6 units of hUC-MSCs in 2 cc secretome combined with 2ml hyaluronic acid (HA), followed by 2ml of HA in the second and third week, showing the improvement of functional and radiological outcome.

These studies showed that MSCs have abilities for giving better results in orthopaedic scopes in regenerative medicine for repair, restore, regenerate and replace.