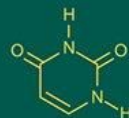


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An insight on Mesenchymal stem cells: A review

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Abstract

The body's stem cells are a special kind of cell that can repair damaged tissue and maintain tissue homeostasis. In contrast to the traditional method of treating diseases by therapeutically repairing the damaged cells, stem cells can multiply widely *in vitro* and replace damaged cells for regeneration. Human body contains undifferentiated cells termed stem cells. They are capable of self-renewal and can differentiate into any form of cell within organism. Both adult and embryonic cells have stem cells. Specialization occurs in stages. With every stage that follows, the developmental potential decreases, suggesting that unipotent stem cell is unable to differentiate into as many distinct cell types as pluripotent stem cell. Recent developments have demonstrated that mesenchymal stem cells (MSCs) have unique characteristics not observed in other stem/progenitor cells, which can be applied in several ways. MSCs have been quoted to be powerful cellular entities that interact with their surroundings and adjacent cells to give therapeutic cell types. With a thorough understanding of complex biology along with therapeutic potential of MSCs, substantial advances in scientific understanding and clinical advantages are expected.

Keywords: Stem cells, Mesenchymal stem cells, pluripotent cells

Introduction

STEM cells classification

According to their origin, stem cells have been categorized as “adult stem cells (ASCs)” or “embryonic stem cells (ESCs)”. Ectoderm, endoderm, and mesoderm are 3 germ layers from which ESCs can differentiate into several cell types due to their pluripotency. On contrary, ASCs, which are isolated from adult tissues, have multipotent to unipotent properties.

STEM cells biology

Adult stem cells, particularly “mesenchymal stem cells (MSCs)”, are distributed as viable substitute for pluripotent stem cells due to their pluripotent characteristics, which are linked to concerns of immune rejection as well as teratoma formation. Since MSCs are pluripotent, they can transdifferentiate into ectoderm and endoderm in addition to mesoderm (Ullah, 2015) [25].

“Embryonic stem cells (ESCs) are derived from inner cell mass of blastocyst, a pre-implantation embryonic stage that happens about four days after fertilization. These cells are then placed in a culture dish that has culture media” in it. A common but ineffective technique for subculturing cells to various dishes is passage. Smaller cell clusters are produced on a new culture surface by cell passaging. Ability of these cells to differentiate into any type of cell within body is what makes them pluripotent. Somatic stem cells have a longer proliferative period than ESCs. Reprogramming adult stem cells to become pluripotent is possible. The adult nucleus can be fused with a pluripotent cell or introduced into the cytoplasm of oocyte for accomplishing this. The cloning of famous “Dolly sheep” was done using the same procedure.

The signals that affect process of stem cell specialization is divided into two categories: internal factors, which are controlled by genetic information in DNA, and external factors, which include chemical secretions from nearby tissues or cellular interaction. Growth hormones and nutrients are necessary for the differentiation and development of stem cells. Medium must be replaced every day.

If stem cells are not differentiated into appropriate cell types for therapy, the entire regenerative medicine procedure will be ineffective.

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Undifferentiated ESCs have potential to develop into teratomas *in vivo*, hence, differentiation is crucial. For regenerative medicine to be effective, it's essential to understand and use signalling pathways for differentiation. Directed differentiation most likely mimics signals that cells acquire as they progress through developing phases (Oh Y, 2019). However, it is challenging to achieve a similar effect *in vivo*. Several variables can be impacted by a signalling molecule's concentration levels and duration of action. A stem cell as well as differentiated cell can be distinguished from one another by their DNA. DNA is loosely arranged with functioning genes in former cell. Unnecessary genes are deactivated as signals enter cell and differentiation process commences, but genes necessary for specific function remain active. It is known that interactions within gene sequences can achieve pluripotency, and this process is reversible.

MSCS and related vascular cell types

"MSCs are spindle-shaped, plastic-adherent cells that can be isolated from adult organs, like bone marrow and various other body tissues", as well as from foetus and extra-embryonic tissues. Friedenstein *et al.*, (1970) [6] first described MSCs as hematopoietic-supporting cells found in bone marrow stroma. These cells can differentiate into multiple mesenchymal tissue lineages, encompassing bone, tendon, cartilage, marrow stroma, ligament, adipocytes, muscle, dermis, and connective tissue, hence, Owen and Friedenstein (1988) [16] suggested that these cells be referred to as MSCs.

Although they come from tissue, are they authentic stem cells *in vivo*? Although MSCs are frequently employed in tissue engineering as well as regenerative medicine, some studies have linked them to previously identified histological cells in bone marrow, including reticulocytes, stromal cells, or fibroblasts. However, since MSCs are so rare, this is unlikely to be the case, and it is still unknown what MSCs appear like *in vivo*. Moreover, whereas bone marrow was initially utilized for isolation of MSCs and regarded as "renewable source, MSC-like cells have been extracted from several tissue sources, encompassing retrieved adipose tissue, umbilical Wharton's jelly, placenta, skin, and roots of shed teeth. Phenotypic similarities among investigations of microvascular pericytes and attempts to assess inherent identity of *in vivo* MSCs were observed by Caplan (2017) [12]. Crisan *et al.* (2012) [4] demonstrated that pericytes isolated via flow cytometry from various human organs and cultured through multiple passages are indistinguishable from traditional, bone marrow-derived MSCs regarding morphology, surface antigen expression, proliferation kinetics, and differentiation potential, both *in vitro* and *in vivo*".

Pericytes as MSC innate forerunners

The perivascular areas surrounding larger arteries and veins were then included in this paradigm, where group of fibroblast-like putative MSCs is found in the outermost tunica adventitia. MSCs can respond rapidly to tissue damage because of their interaction with the vasculature. Whether perivascular cells serve "same progenitor function in their *in vivo* environment is a major unresolved issue surrounding the possible identification of these cells as innate MSC progenitors. Up to one-third of all expressed genes showed significant up regulation or down regulation,

indicating significant differences in gene expression between their development in culture and transition to *in vitro* MSC phenotype."

Properties of MSCS and pericytes

After bone marrow-derived MSCs inhibit T-cells, MSCs can affect inflammatory and immunological responses (Jiang and Xu, 2020) [11]. Additionally, MSCs produce many secretomes and proteomes and secrete several cytokines, growth factors, and chemokines that improve metabolism. These compounds have a major impact on immunomodulatory functions, promoting the differentiation of MSCs, HSC engraftment, and control of angiogenesis and apoptosis (Wu *et al.*, 2020) [29]. Utilizing MSCs' capability of producing cytokines in addition to factors that support innate tissue healing and control inflammation along with immunological responses has become the main emphasis in the past ten years.

MSCS as novel therapy

MSCs have the potential to be a unique treatment method for several disorders because of their incredible capacities for immune regulation and multipotential differentiation (Hoang *et al.*, 2022) [9]. MSCs have also been used in therapeutic studies for myocardial infarction, multiple sclerosis, and type 1 diabetes mellitus (Moreira *et al.*, 2017) [14]. According to research, soluble substances produced by MSCs improve the effectiveness of treatments for autoimmune disorders, which is of great importance. Inflammatory conditions have been the focus of recent research on MSCs' immune-regulatory capabilities (Zaripova *et al.*, 2023) [30].

The transition from "cell replacement to altering body's cellular and tissue responses through clinical perspective represents progress in understanding accessible *ex vivo* expanded MSCs". MSCs' immune modulation as well as anti-inflammatory applications are significantly relevant in damaged tissue.

MSCS for organ transplantation

MSCs are immunoprivileged. Capability of MSCs to avoid negative immune system reactions among people allows them to be transplanted into a variety of persons without the possibility of rejection. These transplants have potent immunosuppressive and anti-inflammatory properties and greatly improve the body's natural healing abilities.

MSCS for regenerative medicine

"MSCs have a considerable capacity for self-renewal while preserving multipotency, similar to other types of stem cells". As a result, MSCs offer substantial therapeutic promise for tissue repair. Numerous cell types, encompassing chondrocytes, osteocytes, adipocytes, and cardiomyocytes, can be differentiated from MSCs.

Understanding and applying signaling pathways for differentiation is essential approach for successful regenerative therapies. Directed differentiation most probably mimics signals that cells acquire as they progress through developmental phases (Cohen & Melton, 2011) [3].

MSCS as inflammatory regulators

Natural killer (NK) cells, B cells, T cells, neutrophils, dendritic cells (DCs), as well as macrophages are among the inflammatory regulator cell types that MSCs can interact

with (Wang *et al.*, 2018) [27]. MSCs have been demonstrated to possess anti-inflammatory properties by secreting several cytokines and chemokines that suppress immunological responses mediated by T cells (Ren *et al.*, 2008) [18]. Inflammation can be reduced and tissue healing accelerated by M2 macrophages. MSCs decrease inflammatory cytokine levels while increasing phagocytic activity and IL-10 release by inducing the production of M2 macrophages. Regenerative along with anti-inflammatory properties of MSCs have made them useful therapeutic agents for a variety of conditions, particularly immunological and bone disorders.

MSCS in autoimmune diseases

Significant amounts of immunosuppressive agents, chemokines, and adhesion molecules are released by mesenchymal stem cells (MSCs) that assist in efficient suppression of T cells, promote T cell proliferation and death, and affect differentiation (Wang *et al.*, 2008) [27]. By blocking the generation of tumor necrosis factor (TNF), MSCs may reduce the proinflammatory potential of DCs. DCs are immunosuppressed by MSCs because they prevent DCs from developing from monocytes and decrease expression of cell-surface markers CD1- α , CD40, CD80, CD83, CD86, as well as MHCII (Tze *et al.*, 2011) [23]. After incubating with MSCs, DCs tend to elevate IL-10 release while down regulating the production of TNF- α as well as interferon- γ (IFN- γ) to reduce their capacity to stimulate lymphocytes (Wang, 2022) [28]. In order to induce MSC-mediated immunosuppression, mechanisms of interaction depend upon cell-cell contact and the synthesis of soluble immune molecules (Song *et al.*, 2020) [22].

MSCS as a target for pharmacological drug testing

Stem cells could be applied to novel pharmacological evaluations. Pluripotent cells can be employed to develop specialized differentiated cells that can be used safely in living tissue experiments. Drug formulations may be modified until they achieve optimal level of efficacy if any negative side effects develop. It is possible to introduce a drug into the pharmaceutical market without endangering any living being. Comparing the effects of the two drugs requires standardizing the conditions in order to evaluate them accurately.

Conclusion

Application of stem cells for treatment is becoming a major therapeutic revolution after many decades of research. Although there are numerous challenges to overcome, the potential of stem cells is growing with each experiment. In both transplantation and regenerative medicine, stem cells have a significant impact. With a thorough understanding of complex biology along with therapeutic potential of MSCs, substantial advances in scientific understanding and clinical advantages are expected.

References

- Aggarwal S, Pittenger MF. Human mesenchymal stem cells modulate allogeneic immune cell responses. *Blood*. 2005;105(4):1815-1822.
- Caplan AI. New MSC: MSCs as pericytes are sentinels and gatekeepers. *J Orthop Res*. 2017;35:1151-1159.
- Cohen DE, Melton D. Turning straw into gold: directing cell fate for regenerative medicine. *Nat Rev Genet*. 2011;12:243-252.
- Crisan M, Corselli M, Chen WC, Péault B. Perivascular cells for regenerative medicine. *J Cell Mol Med*. 2012;16(12):2851-2860.
- Friedenstein AJ. Stromal mechanisms of bone marrow: cloning *in vitro* and retransplantation *in vivo*. *Haematol Blood Transfus*. 1980;25:19-29.
- Friedenstein AJ, Chailakhjan RK, Lalykina KS. The development of fibroblast colonies in monolayer cultures of guinea-pig bone marrow and spleen cells. *Cell Tissue Kinet*. 1970;3(4):393-403.
- Gao WX, Sun YQ, Shi J, Li CL, Fang SB, Wang D, *et al.* Effects of mesenchymal stem cells from human induced pluripotent stem cells on differentiation, maturation, and function of dendritic cells. *Stem Cell Res Ther*. 2017;8(1):48.
- Gebler A, Zabel O, Seliger B. The immunomodulatory capacity of mesenchymal stem cells. *Trends Mol Med*. 2012;18(2):128-134.
- Hoang DM, Pham PT, Bach TQ, Ngo ATL, Nguyen QT, Phan TTK, *et al.* Stem cell-based therapy for human diseases. *Signal Transduct Target Ther*. 2022;7:272.
- Ilic D, Ogilvie C. Concise review: human embryonic stem cells—what have we done? what are we doing? where are we going? *Stem Cells*. 2017;35:17.
- Jiang W, Xu J. Immune modulation by mesenchymal stem cells. *Cell Prolif*. 2020;53(1):e12712.
- Kean TJ, Lin P, Caplan AI, Dennis JE. MSCs: delivery routes and engraftment, cell-targeting strategies, and immune modulation. *Stem Cells Int*. 2013;2013:732742.
- Menasche P, Vanneau V, Hagege A, Bel A, Cholley B, Cacciapuoti I, *et al.* Human embryonic stem cell-derived cardiac progenitors for severe heart failure treatment: first clinical case report. *Eur Heart J*. 2015;36:2011-2017.
- Moreira A, Kahlenberg S, Hornsby P. Therapeutic potential of mesenchymal stem cells for diabetes. *J Mol Endocrinol*. 2017;59(3):R109-R120.
- Oh Y, Jang J. Directed differentiation of pluripotent stem cells by transcription factors. *Mol Cells*. 2019;42(3):200-209.
- Owen M, Friedenstein AJ. Stromal stem cells: marrow-derived osteogenic precursors. *Ciba Found Symp*. 1988;136:42-60.
- Pittenger MF, Discher DE, Peault BM, Phinney DG, Hare JM, Caplan AI. Mesenchymal stem cell perspective: cell biology to clinical progress. *NPJ Regen Med*. 2019;4:22.
- Ren G, Zhang L, Zhao X, Xu G, Zhang Y, Roberts AI, *et al.* Mesenchymal stem cell-mediated immunosuppression occurs via concerted action of chemokines and nitric oxide. *Cell Stem Cell*. 2008;2(2):141-150.
- Rengasamy M, Gupta PK, Kolkundkar U, Singh G, Balasubramanian S, Sundaraj S, *et al.* Preclinical safety and toxicity evaluation of pooled allogeneic human bone marrow-derived mesenchymal stromal cells. *Indian J Med Res*. 2016;144(6):852-864.
- Schwartz SD, Regillo CD, Lam BL, Elliott D, Rosenfeld PJ, Gregori NZ, *et al.* Human embryonic stem cell-

- derived retinal pigment epithelium in patients with age-related macular degeneration and Stargardt's macular dystrophy. *Lancet*. 2015;385:509-516.
21. Shivaswamy V, Boerner B, Larsen J. Post-transplant diabetes mellitus: causes, treatment, and impact on outcomes. *Endocr Rev*. 2016;37(1):37-61.
 22. Song N, Scholtemeijer M, Shah K. Mesenchymal stem cell immunomodulation: mechanisms and therapeutic potential. *Trends Pharmacol Sci*. 2020;41(9):653-664.
 23. Tze LE, Horikawa K, Domaschew H, Howard DR, Roots CM, Rigby RJ, *et al*. CD83 increases MHC II and CD86 on dendritic cells by opposing IL-10-driven MARCH1-mediated ubiquitination. *J Exp Med*. 2011;208(1):149-165.
 24. Uccelli A, Moretta L, Pistoia V. Mesenchymal stem cells in health and disease. *Nat Rev Immunol*. 2008;8(9):726-736.
 25. Ullah I, Subbarao RB, Rho GJ. Human mesenchymal stem cells—current trends and future prospective. *Biosci Rep*. 2015;35(2):e00191.
 26. Wang Y, Chen X, Cao W, Shi Y. Plasticity of mesenchymal stem cells in immunomodulation: pathological and therapeutic implications. *Nat Immunol*. 2014;15(11):1009-1016.
 27. Wang M, Yuan Q, Xie L. Mesenchymal stem cell-based immunomodulation: properties and clinical application. *Stem Cells Int*. 2018;2018:3057624.
 28. Wang Y, Qi Z, Yan Z, Ji N, Yang X, Gao D, *et al*. Mesenchymal stem cell immunomodulation: a novel intervention mechanism in cardiovascular disease. *Front Cell Dev Biol*. 2022;9:742088.
 29. Wu X, Jiang J, Gu Z, Zhang J, Chen Y, Liu X. Mesenchymal stromal cell therapies: immunomodulatory properties and clinical progress. *Stem Cell Res Ther*. 2020;11:345.
 30. Zaripova LN, Midgley A, Christmas SE, Beresford MW, Pain CE, Baildam EM, *et al*. Mesenchymal stem cells in the pathogenesis and therapy of autoimmune and autoinflammatory diseases. *Int J Mol Sci*. 2023;24(22):16040.