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Application and Prospect of Stem Cells in the Treatment of Alopecia

Jihye Ryu[1, a]

[1]High school attached to Shandong Normal University Jinan, 250013, China
[a]Corresponding author's email: kyu1331@naver.com

Abstract: This article introduces the common types of hair loss and the common types of hair loss treatments on the market, such as topical finasteride topical or oral, minoxidil, fractional laser, hair transplantation, etc. And then I introduced the common types of stem cells and described the application of stem cells in the treatment of hair loss. I focused on the extraction methods of ADSCs and the advantages of them. For example, ADSCs have antioxidant effects, promote HF and the formation of peripheral blood vessels, and play a role in regeneration and other effects. Finally, I describe the prospect of stem cells in the treatment of hair loss, especially the drawbacks.

Keywords: ADSCs, Stem cells, Hair loss.

1. Introduction

Hair loss is a disease caused by a variety of hair growth disorders that brings interpersonal sensitivity, depression, fear, anxiety and other adverse effects to patients, and has a great impact on the patient's psychology.[1]

In general, hair loss diseases are divided into two categories: non-scarring and cicatricial alopecia. The former is due to cicatricial folliculitis, leprosy, tertiary syphilis, lichen planus and moss, and the latter is due to alopecia areata, androgenetic alopecia, etc. disease.[2]

At present, the internal causes of hair loss include seborrheic alopecia, telogen effluvium, hypothyroidism, scalp disease, iron deficiency anemia and lupus erythematosus, fungal infection, alopecia areata and frequent washing, aging, endocrine disorders, and excessive mental stress, and so on.[2,3]

At the same time, in addition to metabolic disorders related to the androgen metabolite dihydrotestosterone, it is also associated with decreased blood vessels around the hair follicle and an imbalance of growth factors.[4]

2. Common Treatment Methods and Disadvantages

At present, the methods of treating hair loss include topical or oral finasteride, minoxidil, fractional laser, hair transplantation, etc.[5,6]

However, some treatments for hair loss have unavoidable side effects. Adverse effects such as itching, contact dermatitis, dryness, and facial hirsutism have been reported with topical minoxidil.[7]

Although oral finasteride can treat 95% of male hair loss, only some have been significantly improved. At the same time, minoxidil is associated with male sexual dysfunction, mood disorders, and an increased risk of prostate cancer.[7]

In addition to drug treatment, hair transplant surgery also has certain effects, not only for most types of hair loss patients, but also to improve the appearance of hair loss patients. However, hair transplantation involves the redistribution of autologous dominant resources, so the limited donor area is a limiting factor.[7]

3. Introduction to Stem Cells

Stem cells are a type of cells with self-renewal and multi-lineage differentiation potential and proliferation ability, which are involved in the development and regeneration of tissues and organs[8-9]

It can not only produce progeny cells whose phenotype is completely consistent with the genotype and itself, but also differentiate into progenitor cells. According to the differentiation potential of stem cells, stem cells can be divided into pluripotent stem cells, totipotent stem cells and multipotent stem cells.[3]

According to their different differentiation stages, they can be divided into embryonic stem cells and adult stem cells.[10]

Because of its plasticity, stem cells have great development prospects and potential, and have important clinical and application values.[3]

In addition, stem cells are easy to obtain, less invasive, stably proliferate in vitro, and have a wide range of sources in vivo, all of which have promoted them to become a research hotspot in many fields.[3]

Stem cells could be categorized into several types as follow:

(1) Mesenchymal stem cells (MSCs) are derived from mesoderm with multi-directional differentiation ability and exist in bone marrow, periosteum, muscle and umbilical cord.[10]

It has in-depth research on anti-aging, wound healing, hair/tissue regeneration, etc., and has good effects and safety.[5]

(2) Endothelial progenitor cells (EPC) exist in umbilical cord blood, adult peripheral blood and bone marrow and other parts[10].

(3) Preadipocytes, mainly found in adipose tissue in the body, are mesenchymal cells with a morphology similar to fibroblasts.[10].

(4) Epidermal stem cells have relatively limited differentiation potential and can only differentiate into keratinocytes, hair and sebaceous glands. Its main feature is slow periodicity [10]

4. Application of Stem Cells in Hair Loss

4.1. The Principle of Stem Cell Therapy for Hair Loss

Studies have shown that stem cells can secrete various growth factors such as PDGF, KGF, VECF, etc., which have the potential to promote hair production.[3,11]

Animal experiments have shown that intradermal injection of stem cells or external application of stem cell culture medium to the skin can promote hair follicle growth.[3]

Because stem cell growth factor regulates the hair growth cycle, more hair follicles enter the cell division phase, thereby promoting hair regeneration.[3]

In addition to regulating the hair growth cycle, stem cells can also promote angiogenesis around the hair follicle. [4,12] It promotes the proliferation of hair follicle dermal papilla and stimulates hair follicle from telogen phase to growth phase.[4]

4.2. Detailed Introduction of ADSCs

ADSC has the most extensive sources and is the easiest to obtain, so it has been widely studied and applied. [5]

Adipose-derived stem cells have powerful regeneration, secretion and differentiation capabilities, and can differentiate into epithelial cells, chondrocytes and so on. At the same time, ADSCs can secrete various growth factors [13], through which these factors can regulate the cell cycle, assist in the formation of blood vessels, and have anti-inflammatory and antioxidant effects. Dermal papilla, hair follicle stem cells are stimulated to regenerate and proliferate, which in turn regulates hair growth.[7]

4.3. Extraction Method of ADSCs

There are many methods for the extraction of ADSCs from adipose-derived mesenchymal stem cells, including enzymatic digestion, collagenase combined with tissue block adherence method, tissue block adherence method, mechanical separation method, and suspension culture method. Adipose tissue can be obtained by liposuction, and after a series of operations such as washing, enzymatic digestion, and centrifugation, SVF (stromal vascular) containing ADSCs, pericytes, endothelial cells, lymphocytes, and adipose precursor cells can be obtained. SVFs were then cultured in vitro, and then ADSCs were obtained by passage of adherent cells.[5]

4.4. Mechanism of Action of ADSC

ADSCs can function through four mechanisms.[14]

First: ADSCs have the effect of promoting HF regeneration. The hair follicle is a complex and self-renewing skin-attached micro-organ. Primary hair follicles are characterized by self-renewal and continuous anagen (anagen), anagen (metagen) and telogen (telogen). [2,7,15] However, with age, the self-renewal capacity of HF declines, and HF gradually shows circulatory defects and lack of sensitivity to stimuli. The circulation of HF slows with age (Figure 1A) and progresses to senile alopecia. Homeostasis between inhibitory and activating signals is critical for sustained HF growth. But with aging, activation signals are overtaken by inhibitory signals to become the dominant environmental factor in HF[1,2,7-9].

However, ADSCs can activate two signaling pathways involved in driving HF from telogen to growth phase, because ADSCs can secrete various growth factors, such as IGF, HGF, VEGF, PDGF, etc. [16].

At the heart of this signaling pathway is β-catenin, which actually functions as a Wnt signaling effector and as a transcriptional cofactor for the Lef1/Tcf protein.[17]

Second: ADSCs have anti-inflammatory and antioxidant effects. It is well known that oxidative stress is often accompanied by inflammatory responses, which together cause damage to hair follicles and then cause hair loss. [13] Studies have shown that different types of hair loss are accompanied by local inflammation of the scalp, and even because of androgenetic alopecia, there will be inflammatory cell infiltration around the hair follicle [13]. However, ADSCs can reduce inflammation and fibrosis by inhibiting the corresponding immune processes. [13] In addition to anti-inflammatory effects, ADSCs can also reduce the apoptosis of hair follicle epithelial cells caused by reactive oxygen species and ensure the survival of hair follicles. In conclusion, ADSCs have anti-inflammatory and antioxidant effects, and the synergistic effect of the two can alleviate local inflammation and oxidative stress in hair follicles, reduce hair follicle damage, and reduce the possibility of hair loss.[18]

Third: ADSCs also have the effect of promoting the formation of blood vessels around tissues. Because ADSCs are distributed on the tiny capillaries of fat, they can differentiate into vascular epithelial cells and directly participate in the formation of blood vessels. [10] In this process, factors such as VEGF secreted by ADSCs are involved, which can promote angiogenesis around the hair follicle, provide nutrients required for hair growth, and then promote hair growth. [5] In addition, the role of other growth factors also revolves around this goal, such as VEGF promotes hair follicle vascularization, which can accelerate hair growth, FGF-2 regulates the hair growth cycle, TGF-β induces HF from anagen to anagen, IGF Signals control hair growth cycle and hair shaft differentiation[7]

Fourth: ADSCs have anti-androgenic effects. Studies have shown that androgens affect a series of gene expression and signal transduction processes by acting on androgen receptors of dermal papilla cells, thereby inhibiting hair growth . [13] ADSCs then promote the normal growth of hair through inhibition.

5. Conclusion

Of course, there are still many problems to be solved with this treatment. First, in recent years, studies have shown that the transplantation of pluripotent stem cells has potential tumorigenic risks. [16] Although ADSCs were co-cultured with breast cancer cells in vitro, low expression of anti-apoptotic proteins and apoptosis of breast cancer cells could be observed. Death. But other views suggest that ADSCs promote ovarian cancer metastasis. [5]

Second, the extraction methods of ADSCs, such as amplification environment, dosage, and evaluation criteria, lack uniform standards.[19]

References

[1] Zhang Shu. (2021) Research progress of hair follicle stem cell lineage in the field of hair follicle regeneration. Chinese Journal of Aesthetic Plastic Surgery, 32: 623-626.

[2] Luo Wen. (2016) New progress in the treatment of hair loss with induced pluripotent stem cells. Medical Review, 22: 2745-2747.

[3] Liu Jiawei. (2019) Application status and prospect of stem cells in beauty industry. Journal of Qilu University of Technology, 33: 12-15.

[4] Liu Hongwei. (2021) Expert consensus on research and clinical trials of stem cells in the field of plastic repair and beauty. Chinese Journal of Aesthetic Plastic Surgery, 32: 1-7.

[5] Li Zhujun. (2022) The application of mesenchymal stem cells in the field of plastic surgery. Medical Journal of Peking Union Medical College Hospital, 12.

[6] Lei, M. & Chuong, C.M. (2016) Stem Cells-Aging, alopecia, and stem cells. Science 351, 559-560. DOI: 10.1126/science.aaf1635

[7] Bao Hui. (2021) Research progress of adipose stem cell conditioned medium and micro needling in the treatment of hair loss. Infection, Inflammation, Repair, 22: 179-182.

[8] Ashique S., Sandhu N.K., Haque S.N., et al. (2020) A systemic review on topical marketed formulations, natural products, and oral supplements to prevent androgenic alopecia: a review. Nat Prod Bioprospect, 10: 345-365.

[9] Zhang Y., Andl T., Yang S., et al. (2008) Activation of beta-catenin signaling programs embryonic epidermis to hair follicle fate. Development, 135: 2161-2172.

[10] Yi Chenggang. (2006) Research progress of stem cells and application prospect in plastic and cosmetic surgery. Chinese Journal of Medical Aesthetics and Cosmetology, 12: 190-192.

[11] Ring C.M., Finney R., Avram M. (2022) Lasers, lights, and compounds for hair loss in aesthetics. Clin Dermatol, 40: 64-75.

[12] Yuan Y., Gao J., Liu L., et al. (2013) Role of adipose- derived stem cells in enhancing angiogenesis early after aspirated fat transplantation: induction or differentiation?. Cell Biol Int, 37: 547-550.

[13] Shu Zaiyue. (2020) Mechanism and clinical research progress of adipose-derived stem cells in the treatment of hair loss. Chinese Journal of Aesthetic Plastic Surgery, 31: 63-65.

[14] Li Bin. (2021) Application and prospect of adipose-derived stem cell therapy in plastic surgery. Chinese Journal of Aesthetic Plastic Surgery, 32: 705-708.

[15] Bacakova L., Zarubova J., Travnickova M., et al. (2018) Stem cells: their source, potency and use in regenerative therapies with focus on adipose-derived stem cells-a review. Biotechnol Adv, 36: 1111-1126.

[16] Martinez-Lopez A., Montero-Vilchez T., Sierra-Sánchez Á., et al. (2020) Advanced medical therapies in the management of non-scarring alopecia: areata and androgenic alopecia. Int J Mol Sci, 21: 8390.

[17] Nie C., Yang D., Xu J., et al. (2011) Locally administered adipose-derived stem cells accelerate wound healing through differentiation and vasculogenesis. Cell Transplantation, 20: 205-216.

[18] Guo Rui, Wang Bingqing, Wang Yue. (2020) Research progress of adipose stem cells in facial rejuvenation. Medical Review, 26: 2913-2917, 2923.

[19] Wang T., Guo S., Liu X., et al. (2015) Protective effects of adiposederived stem cells secretome on human dermal fibroblasts from ageing damages. Int J Clin Exp Pathol, 8: 15739-15748.