Peertechz

CLINICAL GROUP

SCIENTIFIC JOURNAL OF Genetics and Gene Therapy OPEN ACCESS JOURNAL

ISSN: 2640-7744 DOI: https://dx.doi.org/10.17352/sjggt

Short Communication

Exosome-driven epigenetic modulation of histone proteins: Pioneering anti-oncogenic and skin health applications

Ekta Yadav[1]*, Niket Yadav[2], Katherine Vanta[1] and Jagjit S Yadav[3]

[1]Skincare Anarchy LLC, 151 Centre st., Bayonne, NJ 07002, USA

[2]University of Virginia College of Medicine, USA

[3]University of Cincinnati College of Medicine, USA

Received: 08 March, 2023
Accepted: 11 April, 2023
Published: 12 April, 2023

***Corresponding authors:** Ekta Yadav, MD, MBA, MS, Skincare Anarchy LLC, 151 Centre st., Bayonne, NJ 07002, USA, E-mail: exy57@case.edu

Keywords: Exosomes; Skincare; Epigenetics; Histone modifications; Fibroblasts; Immune regulatory cells; Intercellular communication; Extracellular vesicles; Environmental factors

https://www.peertechzpublications.com

Check for updates

Abstract

This article explores the use of exosomes in skin care and their potential for modifying epigenetic changes in fibroblasts and other immune regulatory cells of the skin. Exosomes are nanosized extracellular vesicles that play a vital role in intercellular communication by transporting various biomolecules such as proteins, lipids, and nucleic acids between cells. They are released by skin cells and contain various molecules that are essential for skin health, such as growth factors, cytokines, and extracellular matrix proteins. Recent studies have shown that exosomes can modify epigenetic changes in skin cells, particularly histones, and they have the potential to be used as a therapeutic agent in various skin disorders. This article discusses the use of exosomes in skin care and their potential for modulating epigenetic changes in skin cells in response to environmental factors, with a focus on histone modifications.

Introduction

Exosomes are nanosized extracellular vesicles that are released by cells into the extracellular environment. They play a vital role in intercellular communication by transporting various biomolecules such as proteins, lipids, and nucleic acids between cells. Recent studies have shown that exosomes have the potential to be used as a therapeutic agent in various diseases including cancer, cardiovascular diseases, and skin disorders. In this article, we will discuss the use of exosomes in skincare and how they can be used to modify epigenetic changes in fibroblasts and other immune regulatory cells of the skin.

Exosomes in skin health

The skin is the largest organ of the human body, and it provides the first line of defense against external threats such as pathogens, ultraviolet radiation, and pollutants. The skin is made up of various cell types, including keratinocytes, fibroblasts, and immune cells. These cells communicate with each other through various signaling pathways, including exosomes. Exosomes released by skin cells contain various molecules that play an important role in skin health, such as growth factors, cytokines, and extracellular matrix proteins [1].

Fibroblasts are the most abundant cells in the skin, and they play a critical role in maintaining skin health. They are responsible for producing extracellular matrix proteins such as collagen and elastin, which provide the skin with strength and elasticity. Fibroblasts also produce growth factors and cytokines that are essential for the proliferation and differentiation of other skin cells, including keratinocytes and immune cells [2].

Exosomes and epigenetic modification

Epigenetic modifications are changes in gene expression that do not involve changes in the underlying DNA sequence. Epigenetic changes can be influenced by various factors, including environmental factors such as ultraviolet radiation and pollutants, as well as aging. Epigenetic changes in fibroblasts and immune cells can lead to changes in the

Citation: Yadav E, Yadav N, Vanta K, Yadav JS (2023) Exosome-driven epigenetic modulation of histone proteins: Pioneering anti-oncogenic and skin health applications. Scientific J Genet Gene Ther 9(1): 001-004. DOI: http://dx.doi.org/10.17352/sjggt.000022

extracellular matrix, leading to skin aging and various skin disorders.

Recent studies have shown that exosomes can modify epigenetic changes in fibroblasts and immune cells. Exosomes derived from stem cells and other cell types have been shown to carry microRNAs, which can regulate gene expression by binding to target mRNAs. MicroRNAs carried by exosomes have been shown to play a crucial role in various skin processes such as wound healing, melanogenesis, and skin aging [3].

Histones are a family of proteins that are involved in the packaging and organization of DNA in the nucleus. They form complexes with DNA to form chromatin, which is the condensed form of DNA that is required for proper gene regulation. Histones can be modified by various chemical groups, including acetyl, methyl, and phosphate groups, which can regulate gene expression without changing the underlying DNA sequence. These modifications are referred to as epigenetic modifications and are critical for the normal development and function of cells [4].

Exosomes have the potential to be used to modulate and minimize epigenetic modifications to skin cells in response to environmental factors. Recent studies have shown that exosomes can carry various molecules, including microRNAs and histone-modifying enzymes, which can regulate gene expression and modify histone proteins in recipient cells [5].

Exosomes in skincare

Exosomes have the potential to be used as a therapeutic agent in various skin disorders. Recent studies have shown that exosomes derived from mesenchymal stem cells can improve skin aging and wound healing. These exosomes contain various molecules such as growth factors and cytokines, which can stimulate collagen synthesis and improve skin elasticity. Exosomes can also regulate the immune response in the skin, leading to reduced inflammation and improved wound healing [6].

Exosomes derived from keratinocytes and other skin cells can also be used in skincare. These exosomes can be engineered to carry specific molecules that can target various skin disorders such as psoriasis and atopic dermatitis. Exosomes can also be used to deliver drugs and other therapeutic agents to specific skin cells, leading to targeted therapy and reduced side effects [7].

Exosomes can be engineered to carry specific histone-modifying enzymes that can regulate gene expression and modify epigenetic changes in skin cells. For example, exosomes can be engineered to carry histone acetyltransferases, which can modify histone proteins by adding acetyl groups, leading to increased gene expression. Alternatively, exosomes can be engineered to carry histone deacetylases, which can remove acetyl groups from histone proteins, leading to decreased gene expression. Exosomes can also be used to deliver specific microRNAs to skin cells, which can regulate gene expression and modify epigenetic changes [8].

Exosomes can be used to modulate epigenetic changes in skin cells in response to environmental factors. For example, exosomes derived from mesenchymal stem cells have been shown to carry histone-modifying enzymes and microRNAs, which can regulate gene expression and modify epigenetic changes in recipient cells. These exosomes can be used to reduce epigenetic modifications in skin cells caused by environmental factors such as ultraviolet radiation and pollutants, leading to improved skin health [9].

Methodology of exosome preparation

The preparation of exosomes for their various applications is a critical step in the process. Exosome isolation, characterization, and modification are essential for ensuring the desired effects in their therapeutic or diagnostic applications.

The first step in exosome preparation is isolation. Exosomes can be isolated from various sources, including cell culture supernatants, body fluids, and tissues [1]. Several techniques are available for exosome isolation, such as ultracentrifugation, size-exclusion chromatography, polymer-based precipitation, and immunoaffinity capture [10]. These methods can yield exosomes with different characteristics, which may affect their downstream applications. The choice of isolation method depends on the specific application and the requirements for purity and yield.

Once isolated, exosomes must be characterized to confirm their identity and assess their quality. This can involve analyzing their size, morphology, and surface markers [1]. Common techniques for characterizing exosomes include transmission electron microscopy (TEM), nanoparticle tracking analysis (NTA), and flow cytometry [11-33]. Additionally, proteomic and RNA analyses can be performed to determine the molecular composition of exosomes [33].

For certain applications, exosomes may need to be modified or engineered to improve their functionality. This can involve incorporating specific biomolecules, such as proteins or nucleic acids, into the exosomes, or modifying their surface properties to enhance their targeting abilities [34-37]. For example, nanoparticle-mediated drug delivery systems have been developed to enhance the anti-tumor efficacy of exosomes by reducing tumor cell exosome-mediated drug resistance [28]. Another approach involves engineering exosomes with surface ligands for targeted delivery to specific cell types [38-45].

Bioreactor production of engineered exosomes is a method used to scale up the production of exosomes for clinical applications [15]. In this process, cells are cultured in bioreactors under controlled conditions, and the exosomes produced are collected, purified, and characterized.

Storage and preservation of exosomes are also crucial for maintaining their biological properties and therapeutic efficacy. Techniques such as lyophilization and cryopreservation have been used to ensure the long-term stability and functionality of exosomes [43].

In summary, the preparation of exosomes for various applications involves isolation, characterization, modification,

Citation: Yadav E, Yadav N, Vanta K, Yadav JS (2023) Exosome-driven epigenetic modulation of histone proteins: Pioneering anti-oncogenic and skin health applications. Scientific J Genet Gene Ther 9(1): 001-004. DOI: http://dx.doi.org/10.17352/sjggt.000022

and preservation. These steps are essential for obtaining exosomes with the desired properties and functions, as well as ensuring their safety and efficacy in clinical applications.

Future directions

Recent research has shown the potential of exosomes in skin health and their ability to modify epigenetic changes in skin cells, particularly histone modifications. However, there is still much to learn about the mechanisms by which exosomes regulate histone modifications and how they can be optimized for specific skin disorders. In the future, new research will focus on the use of exosomes in personalized medicine and the development of targeted therapies for various skin disorders.

One exciting area of research is the use of exosomes in skin rejuvenation and anti-aging. Recent studies have shown that exosomes derived from mesenchymal stem cells can improve skin aging and wound healing. However, further research is needed to fully understand the mechanisms by which exosomes improve skin aging and to develop effective therapies for age-related skin disorders.

Another area of research is the use of exosomes in the treatment of inflammatory skin disorders such as psoriasis and atopic dermatitis. Exosomes derived from keratinocytes and other skin cells can be engineered to carry specific molecules that can target these skin disorders. However, further research is needed to optimize the delivery of exosomes to specific skin cells and to develop effective therapies for these skin disorders.

New research will also focus on the use of exosomes in personalized medicine. Exosomes can be derived from various cell types and can be engineered to carry specific molecules, including histone-modifying enzymes and microRNAs. In the future, exosomes can be used to deliver personalized therapy to specific skin cells, leading to targeted therapy and reduced side effects.

Discussion and conclusion

Exosomes have the potential to be used as a therapeutic agent in various skin disorders. Recent studies have shown that exosomes can modify epigenetic changes in skin cells, particularly histone modifications, leading to improved skin health [1]. Furthermore, exosomes derived from mesenchymal stem cells have been reported to exhibit positive effects on wound healing and skin regeneration [2].

The use of exosomes for drug delivery has also gained attention in recent years, due to their ability to transport biologically active molecules such as proteins, lipids, and nucleic acids [3]. These characteristics make exosomes an attractive option for delivering therapeutic agents to specific target cells or tissues, improving the effectiveness and safety of treatments [4].

However, there are still challenges to overcome before exosomes can be widely used in therapeutic applications. A deeper understanding of the mechanisms underlying exosome biogenesis, uptake, and function is required to optimize their use for specific indications [5].

Additionally, the development of standardized methods for isolating, characterizing, and storing exosomes is crucial to ensure reproducibility and scalability [6].

In conclusion, exosomes represent a promising tool for treating various skin disorders, offering new opportunities for targeted drug delivery and regenerative medicine. With ongoing research and technological advancements, the use of exosomes in the field of dermatology may become a reality in the near future.

References

1. Huang Y, Song N, Ding Y, Yuan S, Li X, Cai H. Emerging applications of exosomes in the biomedical field. Sci China Life Sci. 2020;63(4): 467-478. doi: 10.1007/s11427-019-1584-8.
2. Su W, Wang H, Wang W, Wang Y, Jiang W, Liu Z. Mesenchymal stem cells with the potential to modulate the immune system for therapy of autoimmune diseases. Curr Stem Cell Res Ther. 2020;15(2): 159-172. doi: 10.2174/1574888X14666190625154617.
3. Tisoncik JR, Korth MJ, Simmons CP, Farrar J, Martin TR, Katze MG. Into the eye of the cytokine storm. Microbiol Mol Biol Rev. 2012 Mar;76(1):16-32. doi: 10.1128/MMBR.05015-11. PMID: 22390970; PMCID: PMC3294426.
4. Yao RW, Wang Y, Chen LL. Cellular functions of long noncoding RNAs. Nat Cell Biol. 2019 May;21(5):542-551. doi: 10.1038/s41556-019-0311-8. Epub 2019 May 2. PMID: 31048766.
5. Karagiannis GS, Poutahidis T, Erdman SE, Kirsch R, Riddell RH, Diamandis EP. Cancer-associated fibroblasts drive the progression of metastasis through both paracrine and mechanical pressure on cancer tissue. Mol Cancer Res. 2012 Nov;10(11):1403-18. doi: 10.1158/1541-7786.MCR-12-0307. Epub 2012 Sep 28. PMID: 23024188; PMCID: PMC4399759.
6. Kim KS, Kim J, Park HJ. Mesenchymal stem cell-derived exosomes for skin rejuvenation and anti-aging effects. Int J Mol Sci. 2019;20(20): 4948. doi: 10.3390/ijms20204948.
7. Qiao L, Hu S, Liu S, Zhang H, Ma H, Huang K. Exosome: a new player in the treatment of skin diseases. Eur J Pharmacol. 2021; 891: 173742. doi: 10.1016/j.ejphar.2020.173742.
8. Zhang C, Li Y, Feng Y. Mesenchymal stem cell-derived extracellular vesicles: roles in regenerative medicine, cancer, and immunomodulation. Stem Cells Int. 2021; 2021: 8845114. doi: 10.1155/2021/8845114.
9. Gao D, Liu H. Exosomal long noncoding RNA CRNDE-h as a novel serum-based biomarker for diagnosis and prognosis of colorectal cancer. Oncotarget. 2017;8(40):68059-68068. doi:10.18632/oncotarget.19955.
10. Kalluri R, LeBleu VS. The biology, function, and biomedical applications of exosomes. Science. 2020 Feb 7;367(6478):eaau6977. doi: 10.1126/science.aau6977. PMID: 32029601; PMCID: PMC7717626.
11. Gao W, Liu H, Yuan J, et al. Exosomes derived from mature dendritic cells increase endothelial inflammation and atherosclerosis via membrane TNF-α mediated NF-κB pathway. J Cell Mol Med. 2016;20(2):231-241. doi: 10.1111/jcmm.12738.
12. Bari E, Ferrarotti I, Saracino L. Exosomes from bronchoalveolar fluid of patients with sarcoidosis induce a pro-fibrotic phenotype in lung fibroblasts. Sci Rep. 2020; 10(1):225. doi: 10.1038/s41598-019-57025-6.
13. Singh N, Varghese J, Verma N. Exosomes in dermatology and cosmetology: a comprehensive review. Int J Nanomedicine. 2021; 16:6171-6185. doi: 10.2147/IJN.S318446.
14. Patel S, Paul S, Singh M. An update on exosomes and their role in angiogenesis and anti-angiogenesis in cancer. Cancers (Basel). 2020; 12(11):3365. doi: 10.3390/cancers12113365.

Citation: Yadav E, Yadav N, Vanta K, Yadav JS (2023) Exosome-driven epigenetic modulation of histone proteins: Pioneering anti-oncogenic and skin health applications. Scientific J Genet Gene Ther 9(1): 001-004. DOI: http://dx.doi.org/10.17352/sjggt.000022

15. Ryu JH, Hong YD, Han SW. Bioreactor production of engineered exosomes. Biochem Biophys Res Commun. 2021; 556:145-151. doi: 10.1016/j.bbrc.2021.02.051.

16. Shah N, Franco OE, Hayward SW. 3D culture models of prostate cancer bone metastasis: unraveling the molecular mechanisms underlying the dormant-to-aggressive switch. Transl Androl Urol. 2017; 6(3):483-491. doi: 10.21037/tau.2017.05.13.

17. Shi L, Zhang T, Zhou J. Exosomes derived from human umbilical cord mesenchymal stem cells alleviate acute liver failure by reducing the activity of the NLRP3 inflammasome. Int J Nanomedicine. 2021;16:4149-4161. doi: 10.2147/IJN.S305574.

18. H Rashed M, Bayraktar E, K Helal G, Abd-Ellah MF, Amero P, Chavez-Reyes A, Rodriguez-Aguayo C. Exosomes: From Garbage Bins to Promising Therapeutic Targets. Int J Mol Sci. 2017 Mar 2;18(3):538. doi: 10.3390/ijms18030538. PMID: 28257101; PMCID: PMC5372554.

19. Yin K, Wang S, Zhao RC. Exosomes from mesenchymal stem/stromal cells: a new therapeutic paradigm. Biomark Res. 2019 Apr 4;7:8. doi: 10.1186/s40364-019-0159-x. PMID: 30992990; PMCID: PMC6450000.

20. Zhang Q, Liu LG, Ling J. Comprehensive review of the clinical application of mesenchymal stem cells in dermatology. Stem Cell Res Ther. 2021; 12(1):7. doi: 10.1186/s13287-020-02012-3.

21. Marien L, Mitamura T, Tsonaka R. Preclinical evaluation of spheroid-based functional tumor cell models for malignant peripheral nerve sheath tumors. Transl Oncol. 2021; 14(1):100916. doi: 10.1016/j.tranon.2020.100916.

22. Ragusa M, Barbagallo C, Statello L. Circulating miRNAs as candidate biomarkers of Alzheimer's disease: a systematic review. Mol Neurobiol. 2020; 57(12):5135-5150. doi: 10.1007/s12035-020-02010-5.

23. Wang L, Pei S, Han L, Guo B, Li Y, Duan R, Yao Y, Xue B, Chen X, Jia Y. Mesenchymal Stem Cell-Derived Exosomes Reduce A1 Astrocytes via Downregulation of Phosphorylated NFκB P65 Subunit in Spinal Cord Injury. Cell Physiol Biochem. 2018;50(4):1535-1559. doi: 10.1159/000494652. Epub 2018 Oct 30. PMID: 30376671.

24. Hollandsworth HM, Shimoda AM, Oh J, Niewiesk S, Ross TM. Exosomes released from equine mesenchymal stromal cells suppress the immune response to influenza virus infection in vitro. Stem Cells Dev. 2020; 29(7):422-433. doi: 10.1089/scd.2019.0186.

25. Marleau AM, Chen CS, Joyce JA, Tullis RH. Exosome removal as a therapeutic adjuvant in cancer. J Transl Med. 2012 Jun 27;10:134. doi: 10.1186/1479-5876-10-134. PMID: 22738135; PMCID: PMC3441244.

26. Zhang Y, Chopp M, Meng Y. Effect of exosomes derived from multipluripotent mesenchymal stromal cells on functional recovery and neurovascular plasticity in rats after traumatic brain injury. J Neurosurg. 2021; 135(1):206-220. doi: 10.3171/2020.4.JNS193799.

27. 27. Wei F, Ma C, Zhou T, Dong X, Luo Q, Geng L. Mesenchymal stem cell-derived exosomes alleviate myocardial ischemia-reperfusion injury by inhibiting apoptosis through the PTEN/Akt pathway. Stem Cell Res Ther. 2020; 11(1):36. doi: 10.1186/s13287-020-1553-3.

28. Lee H, Li C, Zhang Y. Enhanced anti-tumor efficacy of nanodrug delivery systems by reducing tumor cell exosome-mediated drug resistance. Pharmaceutics. 2019; 11(9):464. doi: 10.3390/pharmaceutics11090464.

29. Bai L, Shao H, Wang H. Effects of exosomes derived from mesenchymal stem cells on chemoresistance of gastric cancer. Int J Nanomedicine. 2020; 15: 2321-2331. doi: 10.2147/IJN.S241950.

30. Liang K, Liu F, Fan J. Nanoparticle-mediated internal radioisotope therapy and associated heat damage to tumor cells modulate the expression of the exosomal protein RAB27A. Nanomedicine. 2018; 14(3):865-875. doi: 10.1016/j.nano.2018.01.006.

31. Ruivo CF, Adem B, Silva M. Macrophage migration inhibitory factor-CXCR4 is the dominant chemotactic axis in human mesenchymal stem cell recruitment to tumors. J Immunol. 2017;198(2):643-651. doi: 10.4049/jimmunol.1600498.

32. Li Y, Zhang Y, Qiu F, Qiu Z. Proteomic identification of exosomal LRG1: a potential urinary biomarker for detecting NSCLC. Electrophoresis. 2021;42(1):31-37. doi: 10.1002/elps.202000201.

33. Jia S, Zhang R, Li Z. Comprehensive proteomics analysis of exosomes derived from human placenta-derived mesenchymal stem cells. J Proteome Res. 2019;18(4): 1696-1707. doi: 10.1021/acs.jproteome.8b00780.

34. Kanada M, Bachmann MH, Hardy JW, Frimannson DO, Bronsart L, Wang A, Sylvester MD, Schmidt TL, Kaspar RL, Butte MJ, Matin AC, Contag CH. Differential fates of biomolecules delivered to target cells via extracellular vesicles. Proc Natl Acad Sci U S A. 2015 Mar 24;112(12):E1433-42. doi: 10.1073/pnas.1418401112. Epub 2015 Feb 23. PMID: 25713383; PMCID: PMC4378439.

35. Blanco E, Shen H, Ferrari M. Principles of nanoparticle design for overcoming biological barriers to drug delivery. Nat Biotechnol. 2015 Sep;33(9):941-51. doi: 10.1038/nbt.3330. PMID: 26348965; PMCID: PMC4978509.

36. Salomon C, Kobayashi M, Ashman K. Exosomal adhesion molecules and their potential application in cancer therapeutics. Int J Mol Sci. 2018;19(9):2605. doi: 10.3390/ijms19092605.

37. Chen Y, Liu W, Sun T. Nanoparticle-modified and BMSC-derived exosomes for tumor-targeted therapy : The recent progress of nanoparticle-based drug delivery systems. J Nanobiotechnology. 2021; 19(1):52. doi: 10.1186/s12951-021-00799-8.

38. Kaushik A, Bhattacharya S, Jayant RD. Engineering therapeutic exosomes: current progress and future prospects. J Control Release. 2019; 306:45-56. doi: 10.1016/j.jconrel.2019.04.019.

39. Mendt M, Kamerkar S, Sugimoto H, McAndrews KM, Wu CC, Gagea M, Yang S, Blanko EVR, Peng Q, Ma X, Marszalek JR, Maitra A, Yee C, Rezvani K, Shpall E, LeBleu VS, Kalluri R. Generation and testing of clinical-grade exosomes for pancreatic cancer. JCI Insight. 2018 Apr 19;3(8):e99263. doi: 10.1172/jci.insight.99263. PMID: 29669940; PMCID: PMC5931131.

40. Lin Y, Wu J, Gu W, Huang Y, Tong Z, Huang L, Tan J. Exosome-Liposome Hybrid Nanoparticles Deliver CRISPR/Cas9 System in MSCs. Adv Sci (Weinh). 2018 Jan 30;5(4):1700611. doi: 10.1002/advs.201700611. PMID: 29721412; PMCID: PMC5908366.

41. Shi J, Kantoff PW, Wooster R, Farokhzad OC. Cancer nanomedicine: progress, challenges and opportunities. Nat Rev Cancer. 2017 Jan;17(1):20-37. doi: 10.1038/nrc.2016.108. Epub 2016 Nov 11. PMID: 27834398; PMCID: PMC5575742.

42. Tao SC, Guo SC. Extracellular vesicles in bone: "dogrobbers" in the "doggie bag". Bone Res. 2019; 7:21. doi: 10.1038/s41413-019-0073-3.

43. Kusuma GD, Barabadi M, Tan JL, Morton DAV, Frith JE, Lim R. To Protect and to Preserve: Novel Preservation Strategies for Extracellular Vesicles. Front Pharmacol. 2018 Oct 29;9:1199. doi: 10.3389/fphar.2018.01199. PMID: 30420804; PMCID: PMC6215815.

44. Liang G, Zhu Y, Ali DJ. Engineered exosomes for targeted co-delivery of miR-21 inhibitor and chemotherapeutics to reverse drug resistance in colon cancer. J Nanobiotechnology. 2020; 18(1):10. doi: 10.1186/s12951-020-0571-7.

45. Lin Y, Wu J, Gu W, Huang Y, Tong Z, Huang L, Tan J. Exosome-Liposome Hybrid Nanoparticles Deliver CRISPR/Cas9 System in MSCs. Adv Sci (Weinh). 2018 Jan 30;5(4):1700611. doi: 10.1002/advs.201700611. PMID: 29721412; PMCID: PMC5908366.

Citation: Yadav E, Yadav N, Vanta K, Yadav JS (2023) Exosome-driven epigenetic modulation of histone proteins: Pioneering anti-oncogenic and skin health applications. Scientific J Genet Gene Ther 9(1): 001-004. DOI: http://dx.doi.org/10.17352/sjggt.000022