

World Journal of *Diabetes*

World J Diabetes 2024 November 15; 15(11): 2157-2271



EDITORIAL

- 2157 Diabetes and obesity: A debate on bariatric interventions and its implications
Tatmatsu-Rocha JC, Lima da Silva MR
- 2162 Diabetes mellitus and comorbidities in elderly people from the Lugu community: A critical-reflective analysis
Tatmatsu-Rocha JC, Gomes-Pinto JC
- 2167 Glucagon-like peptide-1 agonists: Role of the gut in hypoglycemia unawareness, and the rationale in type 1 diabetes
Mirghani HO
- 2173 Targeting neuronal PAS domain protein 2 and KN motif/ankyrin repeat domains 1: Advances in type 2 diabetes therapy
Cheng CH, Hao WR, Cheng TH
- 2177 Macrophages: Key players in diabetic wound healing
Zhou X, Guo YL, Xu C, Wang J

EXPERT CONSENSUS

- 2182 Guidelines and consensus: Jejunoileostomy for diabetes mellitus-surgical norms and expert consensus (2023 version)
Shen JW, Ji CY, Fang XD, Yang B, Zhang T, Li ZC, Li HZ, Liu ZY, Tang J, Liao CW, Lu JZ, Yang X, Zhang XG

REVIEW

- 2189 Autophagy-dependent ferroptosis may play a critical role in early stages of diabetic retinopathy
Sun WJ, An XD, Zhang YH, Tang SS, Sun YT, Kang XM, Jiang LL, Zhao XF, Gao Q, Ji HY, Lian FM

ORIGINAL ARTICLE**Basic Study**

- 2203 Effect of exercise during pregnancy on offspring development through ameliorating high glucose and hypoxia in gestational diabetes mellitus
Tang YB, Wang LS, Wu YH, Zhang LX, Hu LY, Wu Q, Zhou ML, Liang ZX
- 2220 Tiliroside protects against diabetic nephropathy in streptozotocin-induced diabetes rats by attenuating oxidative stress and inflammation
Shang Y, Yan CY, Li H, Liu N, Zhang HF

LETTER TO THE EDITOR

- 2237 Role of intestinal glucagon-like peptide-1 in hypoglycemia response impairment in type 1 diabetes
Cheng CH, Hao WR, Cheng TH
- 2242 Atrial fibrillation and prediabetes: Interplay between left atrium and systemic diseases
Hung MJ
- 2245 Glymphatic system function in diverse glucose metabolism states
Byeon H
- 2251 Relationship between age and subfoveal choroidal thickness and its clinical implications
Sinha S, Nishant P, Morya AK, Singh A
- 2255 Bariatric and endo-bariatric interventions for diabetes: What is the current evidence?
Mondal S, Ambrose Fistus V, Pappachan JM
- 2264 Stem cell exosomes: New hope for recovery from diabetic brain hemorrhage
Cheng CH, Hao WR, Cheng TH

ABOUT COVER

Peer Review of *World Journal of Diabetes*, Dimiter Avtanski, PhD, Director, Endocrine Research Laboratory, Friedman Diabetes Institute, Lenox Hill Hospital, New York, NY 10022, United States. davtanski@northwell.edu

AIMS AND SCOPE

The primary aim of *World Journal of Diabetes* (*WJD*, *World J Diabetes*) is to provide scholars and readers from various fields of diabetes with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJD mainly publishes articles reporting research results and findings obtained in the field of diabetes and covering a wide range of topics including risk factors for diabetes, diabetes complications, experimental diabetes mellitus, type 1 diabetes mellitus, type 2 diabetes mellitus, gestational diabetes, diabetic angiopathies, diabetic cardiomyopathies, diabetic coma, diabetic ketoacidosis, diabetic nephropathies, diabetic neuropathies, Donohue syndrome, fetal macrosomia, and prediabetic state.

INDEXING/ABSTRACTING

The *WJD* is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Current Contents/Clinical Medicine, Journal Citation Reports/Science Edition, PubMed, PubMed Central, Reference Citation Analysis, China Science and Technology Journal Database, and Superstar Journals Database. The 2024 Edition of Journal Citation Reports® cites the 2023 journal impact factor (JIF) for *WJD* as 4.2; JIF without journal self cites: 4.1; 5-year JIF: 4.2; JIF Rank: 40/186 in endocrinology and metabolism; JIF Quartile: Q1; and 5-year JIF Quartile: Q2.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Yu-Xi Chen*; Production Department Director: *Xu Guo*; Cover Editor: *Jia-Ru Fan*.

NAME OF JOURNAL

World Journal of Diabetes

ISSN

ISSN 1948-9358 (online)

LAUNCH DATE

June 15, 2010

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Lu Cai, Md. Shahidul Islam, Michael Horowitz

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/1948-9358/editorialboard.htm>

PUBLICATION DATE

November 15, 2024

COPYRIGHT

© 2024 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>

Macrophages: Key players in diabetic wound healing

Xin Zhou, Yan-Ling Guo, Chuan Xu, Jun Wang

Specialty type: Endocrinology and metabolism

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade C, Grade C

Novelty: Grade B, Grade B

Creativity or Innovation: Grade B, Grade B

Scientific Significance: Grade B, Grade B

P-Reviewer: Li Y; Li J

Received: July 21, 2024

Revised: September 3, 2024

Accepted: September 18, 2024

Published online: November 15, 2024

Processing time: 86 Days and 21.3 Hours



Xin Zhou, Department of Science and Education, Huzhou Traditional Chinese Medicine Hospital Affiliated to Zhejiang Chinese Medical University, Huzhou 313000, Zhejiang Province, China

Yan-Ling Guo, Jun Wang, Department of Ulcers and Peripheral Vascular Surgery, First Teaching Hospital of Tianjin University of Traditional Chinese Medicine, National Clinical Research Center for Chinese Medicine Acupuncture Moxibustion, Tianjin 300381, China

Chuan Xu, Department of Pharmacy, Huzhou Traditional Chinese Medicine Hospital Affiliated to Zhejiang Chinese Medical University, Huzhou 313000, Zhejiang Province, China

Co-corresponding authors: Xin Zhou and Jun Wang.

Corresponding author: Jun Wang, MD, Chief Doctor, Professor, Department of Ulcers and Peripheral Vascular Surgery, First Teaching Hospital of Tianjin University of Traditional Chinese Medicine, National Clinical Research Center for Chinese Medicine Acupuncture Moxibustion, No. 88 Changling Road, Xiqing District, Tianjin 300381, China.

tjzywangjun@126.com

Abstract

In this editorial, we discuss the article by Wen *et al* published. Diabetic foot ulcers are prevalent and serious complications of diabetes, significantly impacting patients' quality of life and often leading to disability or death, thereby placing a heavy burden on society. Effective diabetic wound healing is hindered by an imbalance in macrophage polarization; many macrophages fail to transition from the pro-inflammatory M1 phenotype to the anti-inflammatory M2 phenotype, which is crucial for tissue remodelling and repair. The wound healing process is both dynamic and complex. Healthy M1 macrophages, which have strong phagocytic abilities, are vital during the inflammatory phase of diabetic wound healing. However, the failure to transition to M2 macrophages during the proliferative phase hinders wound healing. We anticipate the development of new therapies that can repair damaged M1 macrophages during the inflammatory phase and promote M2 macrophage polarization during the proliferative phase, thereby enhancing the overall healing process.

Key Words: Diabetic wound healing; Macrophages; Inflammation; Exosomes; Natural medicines

©The Author(s) 2024. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: In this editorial, we discuss the recently published article by Wen *et al.* Despite significant scientific efforts worldwide, diabetic foot ulcers remain a challenging issue. The authors highlighted the importance of macrophage polarization in diabetic wound healing, and we strongly endorse this perspective. However, we emphasize that future research should also recognize the essential role of healthy M1 macrophages in the diabetic wound healing process.

Citation: Zhou X, Guo YL, Xu C, Wang J. Macrophages: Key players in diabetic wound healing. *World J Diabetes* 2024; 15(11): 2177-2181

URL: <https://www.wjgnet.com/1948-9358/full/v15/i11/2177.htm>

DOI: <https://dx.doi.org/10.4239/wjcd.v15.i11.2177>

INTRODUCTION

Diabetes is a prevalent and significant clinical condition. By 2045, an estimated 783.2 million people worldwide will have diabetes, presenting a major public health challenge and causing a substantial societal burden[1]. Among the most common complications are wound healing disorders, particularly diabetic foot ulcers (DFU). Between 19% and 34% of diabetic patients develop foot ulcers, which are the leading cause of amputation in these individuals[2]. Alarmingly, up to 70% of patients may die within five years after amputation[3]. In underdeveloped regions, inadequate public sanitation and a lack of professional wound care exacerbate complications, leading to severe infections and poor prognoses[4]. Thus, promoting effective wound healing remains a significant challenge for the medical community.

Scientometrics (bibliometrics) has emerged as a valuable tool for analysing the impact, characteristics, and trends of research on specific topics. While it has limitations compared to traditional reviews, bibliometric analysis can reveal research trends and key points, providing constructive insights for future studies[5]. Wen *et al*[6] utilized scientometrics to offer a comprehensive overview of macrophage-related DFU research. Their study highlights the complexity of macrophage phenotypic switching in diabetic wounds and highlights the potential role of exosomes as a burgeoning area of research.

WOUND HEALING AND MACROPHAGE POLARIZATION

Wound healing is a complex and precise biological process involving interactions among various cell types and mediators. It progresses through four main stages: Haemostasis (immediately post-injury), inflammation (1-4 days), proliferation(4-21 days), and remodelling (21 days to 2 years)[7]. Compared with healthy individuals, slow wound healing is a significant feature of diabetes. The slow onset and delayed resolution of wound inflammation are major factors contributing to healing difficulties in diabetic patients. Macrophages play crucial roles in both the initiation and resolution of wound inflammation.

Macrophages exhibit notable heterogeneity and plasticity, resulting in different phenotypes depending on the microenvironment. The classical macrophage polarization model involves two opposite phenotypic states: “classically” activated M1 macrophages, which are induced by lipopolysaccharide or interferon- γ , and “alternatively” activated M2 macrophages, which are triggered by interleukin-13 (IL-13) or IL-4[8]. M1 macrophages primarily exert pro-inflammatory, anti-infection, and anti-tumour immune functions, often resulting in inflammation and autoimmune diseases. In contrast, M2 macrophages exhibit anti-inflammatory and tissue repair functions but can promote tumour progression[9]. Macrophage activation is currently believed to occur on a continuous spectrum, with M1 and M2 representing the two extremes. Macrophage polarization is dynamically reversible, meaning that M1 macrophages can switch to M2 macrophages and vice versa as microenvironmental conditions change[10].

Macrophages are involved in nearly all stages of wound healing, particularly during the inflammatory and proliferative phases. At the onset of wound inflammation, macrophages are recruited to the affected area and transform into the M1 type under the influence of pro-inflammatory factors, engulfing necrotic tissue and apoptotic neutrophils. As inflammation subsides and the proliferative phase begins, wounded macrophages predominantly polarized toward the M2 type, promoting healing through inflammation suppression, angiogenesis, re-epithelialization, and other processes [11]. Notably, the phagocytic function of M1 macrophages plays a critical role in the phenotypic transition of wounded macrophages[12]. Additionally, macrophages activated in high-glucose environments are more prone to adopt a senescent phenotype, further complicating the M1-to-M2 transition[13]. Therefore, the balance between M1 and M2 macrophage polarization is essential for the clearance of necrotic tissue, resolution of inflammation, and tissue repair in wounds. Accelerating wound healing by using drugs or immunosuppressants to polarize macrophages towards a pro-repair subtype or recruiting macrophage subpopulations prior to wound healing is a common therapeutic strategy.

IMBALANCE OF MACROPHAGE POLARIZATION IN DIABETIC WOUNDS

Diabetes is a metabolic disorder that induces low-grade systemic inflammation, significantly impacting the immune

system. Dysregulated metabolic pathways and immune abnormalities affect every stage of wound healing[14]. A key issue is the imbalance of macrophage polarization. An RNA sequencing study of wound tissues from patients with DFU and healthy subjects revealed a higher M1/M2 ratio in DFU tissues than in healthy skin[15]. High-glucose environments, hypoxia, and the formation of advanced glycation end products reduce the phagocytic activity of M1 macrophages. In the diabetic wound environment, however, M1 macrophages secrete proinflammatory cytokines such as IL-1 β , IL-6, and tumor necrosis factor- α , which attract circulating monocytes to the site of inflammation and drive their differentiation into the M1 phenotype. This accumulation of M1 macrophages in chronic wounds impedes their transition to the M2 phenotype, preventing the wound from progressing from the inflammatory phase to the proliferative granulation phase. As a result, chronic inflammation persists, leading to impaired wound healing[16].

Current research has focused primarily on therapies aimed at promoting wound healing by inducing macrophage polarization towards the M2 phenotype[17,18]. For example, the topical application of a macrophage-regulating drug such as ON101 cream reduces the activity of inflammatory M1 macrophages while enhancing the M2 macrophage population through granulocyte colony-stimulating factor-mediated M2 polarization. This shift facilitates the transition of the ulcer from the inflammatory phase to the proliferative and remodelling phases, promoting wound healing[19]. However, whether these therapies can repair damaged M1 macrophages and enable their spontaneous and stable polarization toward the M2 phenotype remains an open question and requires further investigation.

EXOSOMES: A PROMISING THERAPEUTIC STRATEGY

Exosomes are extracellular vesicles containing lipids, proteins, RNA, and DNA that serve as key mediators of intercellular communication. Throughout the various stages of diabetic wound healing, exosomes regulate the functions of macrophages, endothelial cells, fibroblasts, and keratinocytes. This regulation is crucial for inhibiting excessive inflammation, promoting angiogenesis, and facilitating collagen synthesis[20].

Recent studies have highlighted the potential of exosomes to modulate macrophage phenotypes in diabetic wounds. Shi *et al*[21] discovered that hypoxic bone marrow mesenchymal stem cells-derived exosomes loaded hydrogel alleviate macrophage dysfunction by inhibiting SREBP2 activity, promoting the polarization of macrophages to the M2 phenotype, and thereby promoting diabetic wound healing. Similarly, Liu *et al*[22] reported that melatonin-stimulated mesenchymal stem cell-derived exosomes improve diabetic wound healing by targeting the phosphatase and tensin homolog/protein kinase B pathway to regulate macrophage polarization between the M1 and M2 phenotypes. Furthermore, Cheng *et al*[23] demonstrated that hypoxic human umbilical vein endothelial cells-derived exosomes enhance endothelial cell function under high-glucose conditions by increasing the expression of the long non-coding RNA HAR1B, reducing oxidative stress and inflammatory responses, and promoting KLF transcription factor 4 expression *via* interaction with the transcription factor basic helix-loop-helix family member e23; thus, these exosomes increase angiogenesis and promote the polarization of macrophages toward the M2 phenotype, ultimately accelerating diabetic wound healing.

CONCLUSION

Bibliometrics provides a comprehensive perspective on macrophage-related DFU research and facilitates interdisciplinary integration and collaboration. Macrophage phenotypic switching plays a crucial role in immune-related diseases, particularly in inflammation-driven conditions such as diabetic wounds. Most current research focuses on promoting the polarization of macrophages toward the M2 phenotype. However, the wound healing process is dynamic and complex and requires robust M1 macrophages with strong phagocytic abilities during the initial phases of healing[24]. Future research should explore the balance between M1 and M2 macrophages in wound healing. We look forward to the emergence of new therapies that can repair damaged M1 macrophages during the inflammatory phase and promote M2 macrophage polarization during the proliferative phase, resulting in sequential promotion.

In addition, natural medicines offer promising alternatives to synthetic drugs, particularly in the treatment of diabetic wounds. Unlike single-target synthetic therapies, natural medicines often provide multitarget, synergistic effects, which can increase their therapeutic potential[25]. Many natural compounds have been shown to regulate the activity of macrophages, which is key in diabetic wound healing. For example, Song *et al*[26] demonstrated that *Sanguisorba officinalis* L. promotes diabetic wound healing by inhibiting the nuclear factor- κ B (NF- κ B)/NOD-like receptor family pyrin domain containing 3 signalling pathway, thereby increasing the ratio of M2 to M1 macrophages. Similarly, Li *et al*[27] reported that apigenin accelerates wound healing in diabetic mice by upregulating the expression of miR-21, which inhibits the toll-like receptor 4/myeloid differentiation factor 88/NF- κ B signalling axis and promotes M2 macrophage polarization. Recent advancements have also highlighted the effectiveness of hydrogels infused with natural medicines for treating diabetic wounds. For example, hydrogels containing Wormwood essential oil and *Ganoderma lucidum* polysaccharides have shown excellent mechanical properties, strong tissue adhesion, and notable antibacterial, anti-inflammatory, and antioxidant effects. These anti-inflammatory benefits are partly mediated by the ability of hydrogels ability to promote M2 macrophage polarization[28,29]. In the management of diabetic wounds, blood glucose control remains crucial. Natural medicines not only facilitate wound healing but also help regulate blood glucose levels, making them a promising and holistic therapeutic approach[30].

FOOTNOTES

Author contributions: Zhou X and Wang J conceptualized and designed the editorial, they contributed equally to this editorial and as co-corresponding authors; Guo YL and Xu C contributed to data collection and manuscript editing; Zhou X drafted the manuscript. All authors have reviewed and approved the final version of the manuscript.

Supported by Key Project of the Huzhou City Science and Technology Plan, No. 2023GZ83.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <https://creativecommons.org/licenses/by-nc/4.0/>

Country of origin: China

ORCID number: Xin Zhou 0000-0003-4399-7915; Yan-Ling Guo 0009-0000-8071-1811; Jun Wang 0000-0002-1756-5193.

S-Editor: Wang JJ

L-Editor: A

P-Editor: Wang WB

REFERENCES

- Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, Stein C, Basit A, Chan JCN, Mbanya JC, Pavkov ME, Ramachandran A, Wild SH, James S, Herman WH, Zhang P, Bommer C, Kuo S, Boyko EJ, Magliano DJ. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res Clin Pract* 2022; **183**: 109119 [PMID: 34879977 DOI: 10.1016/j.diabres.2021.109119]
- Armstrong DG, Boulton AJM, Bus SA. Diabetic Foot Ulcers and Their Recurrence. *N Engl J Med* 2017; **376**: 2367-2375 [PMID: 28614678 DOI: 10.1056/NEJMra1615439]
- Edmonds M, Lázaro-Martínez JL, Alfayate-García JM, Martini J, Petit JM, Rayman G, Lobmann R, Uccioli L, Sauvadet A, Bohbot S, Kerihuel JC, Piaggese A. Sucrose octasulfate dressing versus control dressing in patients with neuroischaemic diabetic foot ulcers (Explorer): an international, multicentre, double-blind, randomised, controlled trial. *Lancet Diabetes Endocrinol* 2018; **6**: 186-196 [PMID: 29275068 DOI: 10.1016/S2213-8587(17)30438-2]
- Armstrong DG, Tan TW, Boulton AJM, Bus SA. Diabetic Foot Ulcers: A Review. *JAMA* 2023; **330**: 62-75 [PMID: 37395769 DOI: 10.1001/jama.2023.10578]
- Li X, Chen W, Ren J, Gao X, Zhao Y, Song T, Fu K, Zheng Y, Yang J. Effects of curcumin on non-alcoholic fatty liver disease: A scientific metrogy study. *Phytomedicine* 2024; **123**: 155241 [PMID: 38128395 DOI: 10.1016/j.phymed.2023.155241]
- Wen JP, Ou SJ, Liu JB, Zhang W, Qu YD, Li JX, Xia CL, Yang Y, Qi Y, Xu CP. Global trends in publications regarding macrophages-related diabetic foot ulcers in the last two decades. *World J Diabetes* 2024; **15**: 1627-1644 [PMID: 39099825 DOI: 10.4239/wjd.v15.i7.1627]
- Yazarlu O, Iranshahi M, Kashani HRK, Reshadat S, Habtemariam S, Iranshahi M, Hasanpour M. Perspective on the application of medicinal plants and natural products in wound healing: A mechanistic review. *Pharmacol Res* 2021; **174**: 105841 [PMID: 34419563 DOI: 10.1016/j.phrs.2021.105841]
- Funes SC, Rios M, Escobar-Vera J, Kalergis AM. Implications of macrophage polarization in autoimmunity. *Immunology* 2018; **154**: 186-195 [PMID: 29455468 DOI: 10.1111/imm.12910]
- Kadomoto S, Izumi K, Mizokami A. Macrophage Polarity and Disease Control. *Int J Mol Sci* 2021; **23** [PMID: 35008577 DOI: 10.3390/ijms23010144]
- Xu W, Zhao X, Daha MR, van Kooten C. Reversible differentiation of pro- and anti-inflammatory macrophages. *Mol Immunol* 2013; **53**: 179-186 [PMID: 22944456 DOI: 10.1016/j.molimm.2012.07.005]
- Barman PK, Koh TJ. Macrophage Dysregulation and Impaired Skin Wound Healing in Diabetes. *Front Cell Dev Biol* 2020; **8**: 528 [PMID: 32671072 DOI: 10.3389/fcell.2020.00528]
- Zhong X, Lee HN, Kim SH, Park SA, Kim W, Cha YN, Surh YJ. Myc-nick promotes efferocytosis through M2 macrophage polarization during resolution of inflammation. *FASEB J* 2018; **32**: 5312-5325 [PMID: 29718706 DOI: 10.1096/fj.201800223R]
- Wilkinson HN, Clowes C, Banyard KL, Matteuci P, Mace KA, Hardman MJ. Elevated Local Senescence in Diabetic Wound Healing Is Linked to Pathological Repair via CXCR2. *J Invest Dermatol* 2019; **139**: 1171-1181.e6 [PMID: 30684552 DOI: 10.1016/j.jid.2019.01.005]
- Patel S, Srivastava S, Singh MR, Singh D. Mechanistic insight into diabetic wounds: Pathogenesis, molecular targets and treatment strategies to pace wound healing. *Biomed Pharmacother* 2019; **112**: 108615 [PMID: 30784919 DOI: 10.1016/j.biopha.2019.108615]
- Jiang N, Xu C, Xu Y, Zhuo Y, Chen P, Deng S, Zhao Z, Long Y, Bai X, Wang Q, Chen Q. Comprehensive transcriptomic analysis of immune-related genes in diabetic foot ulcers: New insights into mechanisms and therapeutic targets. *Int Immunopharmacol* 2024; **139**: 112638 [PMID: 39079197 DOI: 10.1016/j.intimp.2024.112638]
- Cai Y, Chen K, Liu C, Qu X. Harnessing strategies for enhancing diabetic wound healing from the perspective of spatial inflammation patterns. *Bioact Mater* 2023; **28**: 243-254 [PMID: 37292231 DOI: 10.1016/j.bioactmat.2023.04.019]
- Wang L, Xue B, Zhang X, Gao Y, Xu P, Dong B, Zhang L, Zhang L, Li L, Liu W. Extracellular Matrix-Mimetic Intrinsic Versatile Coating Derived from Marine Adhesive Protein Promotes Diabetic Wound Healing through Regulating the Microenvironment. *ACS Nano* 2024; **18**: 14726-14741 [PMID: 38778025 DOI: 10.1021/acsnano.4c03626]
- Wang S, Zhang Y, Zhong Y, Xue Y, Liu Z, Wang C, Kang DD, Li H, Hou X, Tian M, Cao D, Wang L, Guo K, Deng B, McComb DW, Merad

- M, Brown BD, Dong Y. Accelerating diabetic wound healing by ROS-scavenging lipid nanoparticle-mRNA formulation. *Proc Natl Acad Sci U S A* 2024; **121**: e2322935121 [PMID: 38771877 DOI: 10.1073/pnas.2322935121]
- 19 **Huang YY**, Lin CW, Cheng NC, Cazzell SM, Chen HH, Huang KF, Tung KY, Huang HL, Lin PY, Perng CK, Shi B, Liu C, Ma Y, Cao Y, Li Y, Xue Y, Yan L, Li Q, Ning G, Chang SC. Effect of a Novel Macrophage-Regulating Drug on Wound Healing in Patients With Diabetic Foot Ulcers: A Randomized Clinical Trial. *JAMA Netw Open* 2021; **4**: e2122607 [PMID: 34477854 DOI: 10.1001/jamanetworkopen.2021.22607]
- 20 **Li D**, Wu N. Mechanism and application of exosomes in the wound healing process in diabetes mellitus. *Diabetes Res Clin Pract* 2022; **187**: 109882 [PMID: 35487341 DOI: 10.1016/j.diabres.2022.109882]
- 21 **Shi Y**, Wang S, Wang K, Yang R, Liu D, Liao H, Qi Y, Qiu K, Hu Y, Wen H, Xu K. Relieving Macrophage Dysfunction by Inhibiting SREBP2 Activity: A Hypoxic Mesenchymal Stem Cells-Derived Exosomes Loaded Multifunctional Hydrogel for Accelerated Diabetic Wound Healing. *Small* 2024; **20**: e2309276 [PMID: 38247194 DOI: 10.1002/smll.202309276]
- 22 **Liu W**, Yu M, Xie D, Wang L, Ye C, Zhu Q, Liu F, Yang L. Melatonin-stimulated MSC-derived exosomes improve diabetic wound healing through regulating macrophage M1 and M2 polarization by targeting the PTEN/AKT pathway. *Stem Cell Res Ther* 2020; **11**: 259 [PMID: 32600435 DOI: 10.1186/s13287-020-01756-x]
- 23 **Cheng P**, Xie X, Hu L, Zhou W, Mi B, Xiong Y, Xue H, Zhang K, Zhang Y, Hu Y, Chen L, Zha K, Lv B, Lin Z, Lin C, Dai G, Hu Y, Yu T, Hu H, Liu G, Zhang Y. Hypoxia endothelial cells-derived exosomes facilitate diabetic wound healing through improving endothelial cell function and promoting M2 macrophages polarization. *Bioact Mater* 2024; **33**: 157-173 [PMID: 38034500 DOI: 10.1016/j.bioactmat.2023.10.020]
- 24 **Raziyeva K**, Kim Y, Zharkinbekov Z, Kassymbek K, Jimi S, Saparov A. Immunology of Acute and Chronic Wound Healing. *Biomolecules* 2021; **11** [PMID: 34066746 DOI: 10.3390/biom11050700]
- 25 **Zhou X**, Guo Y, Yang K, Liu P, Wang J. The signaling pathways of traditional Chinese medicine in promoting diabetic wound healing. *J Ethnopharmacol* 2022; **282**: 114662 [PMID: 34555452 DOI: 10.1016/j.jep.2021.114662]
- 26 **Song J**, Zeng J, Zheng S, Jiang N, Wu A, Guo S, Ye R, Hu L, Huang F, Wang L, Xiaogang Z, Liu B, Wu J, Chen Q. Sanguisorba officinalis L. promotes diabetic wound healing in rats through inflammation response mediated by macrophage. *Phytother Res* 2023; **37**: 4265-4281 [PMID: 37260161 DOI: 10.1002/ptr.7906]
- 27 **Li K**, Wu L, Jiang J. Apigenin accelerates wound healing in diabetic mice by promoting macrophage M2-type polarization *via* increasing miR-21 expression. *Mol Cell Biochem* 2024; **479**: 3119-3127 [PMID: 38261238 DOI: 10.1007/s11010-023-04885-y]
- 28 **Wang F**, Sun Q, Li Y, Xu R, Li R, Wu D, Huang R, Yang Z, Li Y. Hydrogel Encapsulating Wormwood Essential Oil with Broad-spectrum Antibacterial and Immunomodulatory Properties for Infected Diabetic Wound Healing. *Adv Sci (Weinh)* 2024; **11**: e2305078 [PMID: 38030556 DOI: 10.1002/advs.202305078]
- 29 **Li F**, Liu T, Liu X, Han C, Li L, Zhang Q, Sui X. Ganoderma lucidum polysaccharide hydrogel accelerates diabetic wound healing by regulating macrophage polarization. *Int J Biol Macromol* 2024; **260**: 129682 [PMID: 38266851 DOI: 10.1016/j.ijbiomac.2024.129682]
- 30 **Liu Y**, Zhang X, Yang L, Zhou S, Li Y, Shen Y, Lu S, Zhou J, Liu Y. Proteomics and transcriptomics explore the effect of mixture of herbal extract on diabetic wound healing process. *Phytomedicine* 2023; **116**: 154892 [PMID: 37267693 DOI: 10.1016/j.phymed.2023.154892]



Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: <https://www.f6publishing.com/helpdesk>
<https://www.wjgnet.com>

