

# Research Progress on the Treatment of Diabetic Foot Ulcers with Traditional Chinese Medicine Preparations

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**Abstract:** Diabetic foot ulcer (DFU) is a prevalent and severe complication in diabetic patients, characterized by high morbidity, challenging treatment, prolonged healing duration, and substantial medical costs. It stands as a primary cause of disability and even mortality among diabetics. Traditional Chinese medicine (TCM) preparations, including ointments, granules, powders, and decoctions, have demonstrated remarkable efficacy in accelerating wound healing in diabetic patients. Modern pharmacological research reveals that TCM formulas and their active constituents effectively facilitate diabetic wound healing through multifaceted regulatory mechanisms, influencing cell proliferation, angiogenesis, collagen deposition, oxidative stress, and inflammation. This article primarily summarizes the TCM preparations that are efficacious in treating diabetic wounds, aiming to provide a reference for future in-depth research and clinical application.

**Keywords:** Traditional Chinese Medicine; Herbal Formulation; Diabetes Wounds; Dosage Form.

## 1. Introduction

Aging population, dietary shifts, and sedentary lifestyles are significant contributors to the steady rise in global diabetes cases, affecting over 300 million individuals worldwide[1]. With the increasing number of diabetes cases, the incidence of diabetic foot ulcers is also rising[2]. These chronic wounds impair patients' quality of life and significantly elevate their risk of mortality. Skin regeneration in normal wounds undergoes four distinct stages: hemostasis, inflammatory response, cellular proliferation, and remodeling[3]. Unlike normal skin wounds, diabetic ulcer wounds exhibit severe inflammation and ischemia, hindering their progression to the proliferation and remodeling stages[4].

Numerous factors impact wound healing in diabetic patients, including recurrent microbial infections, excessive accumulation of reactive oxygen species (ROS), cellular dysfunction and senescence, as well as impaired angiogenesis. *Staphylococcus aureus* and *Escherichia coli* are the primary bacteria causing severe wound infections[5]. These bacteria form bacterial biofilms and secrete virulence factors, enhancing bacterial resistance and invasiveness, causing damage to angiogenesis and immune cells, promoting inflammatory responses, and rendering the treatment of infectious wounds more challenging[6]. Furthermore, in a hyperglycemic state, excessive ROS produced by neutrophils and macrophages not only initiates and exacerbates inflammatory responses but also disrupts the behavior of functional cells such as fibroblasts and endothelial cells, leading to impaired extracellular matrix (ECM) remodeling, reduced angiogenesis, and delayed re-epithelialization[7]. These sequential changes ultimately result in tissue ischemia and hypoxia, thereby delaying the wound healing process. Therefore, controlling blood glucose levels, improving microcirculation, and increasing oxygen supply are particularly crucial in the treatment of diabetic wounds[4].

Currently, anti-inflammatory drugs, exosomes, and growth factors are widely used in the treatment of chronic inflammation and wound healing. However, these treatment methods also pose issues such as drug resistance, side effects,

and high costs. Most wound matrices used for normal skin regeneration exhibit poor healing capabilities in chronic wounds[8, 9]. In recent years, the application of traditional Chinese medicinal herbs (TCMH) in the treatment of diabetic wounds has become increasingly widespread, with significant advancements in exploring the wound-healing activities and underlying mechanisms of these botanicals. Various TCMH have been formulated into multiple dosage forms, including decoctions, tinctures, ointments, granules, capsules, and more, as illustrated in Figure 1. Modern pharmacological studies have revealed that TCMH contain a multitude of active ingredients, which exert therapeutic effects on diabetic wounds through multiple signaling pathways, including Wnt, MAPK, Nrf2/ARE, Notch, and Vascular Endothelial Growth Factor (VEGF) signaling pathways[10]. Therefore, this article primarily summarizes the plant-based medicines within traditional Chinese medicine that possess wound-healing properties, aiming to provide a reference for in-depth research and practical applications in this field.

## 2. Ointments

Topical ointments are widely used in clinical practice due to their advantages such as ease of application, cleanliness, simplicity in use, direct absorption on the wound surface, and effective avoidance of the liver's "first-pass effect". They exhibit promising clinical application prospects[11].

According to the research results, the Lithospermum component in Zizhu Ointment demonstrates significant anti-inflammatory and antibacterial effects, effectively reducing inflammatory responses and subsequently helping to decrease the levels of inflammatory cytokines. In patients with early-stage diabetic foot ulcers, the adoption of traditional Chinese medicine nursing intervention combined with external application of Zizhu Ointment can lower the levels of TNF- $\alpha$  and IL-6, effectively promoting wound healing[12]. Experimental evidence also indicates that Zizhu Ointment can reduce the expression level of iNOS RNA in ulcerated tissue in mice, increase the expression levels of IL-4 and IL-10 RNA, upregulate the expression of snail,  $\beta$ -catenin, and  $\alpha$ -SMA, and

downregulate the expression of E-cadherin. Therefore, Zizhu Ointment may promote the healing of diabetic ulcers by reducing inflammatory responses and facilitating epithelial-mesenchymal transition[13]. Additionally, a study on the treatment of type 2 diabetic foot ulcers with Shengji Xiangpi Gao combined with Mupirocin Ointment found that it significantly improved wound healing and exhibited good clinical efficacy, making it suitable for wound treatment in diabetic foot ulcers[14]. The combined application of

Compound Polymyxin B Ointment and recombinant human epidermal growth factor (rhEGF) has demonstrated significant therapeutic effects in the treatment of refractory diabetic skin ulcers. It can effectively debride necrotic tissue and promote skin growth, reduce dressing change frequency, improve patients' blood glucose levels, and enhance the quality of life for patients with refractory diabetic skin ulcers[15].

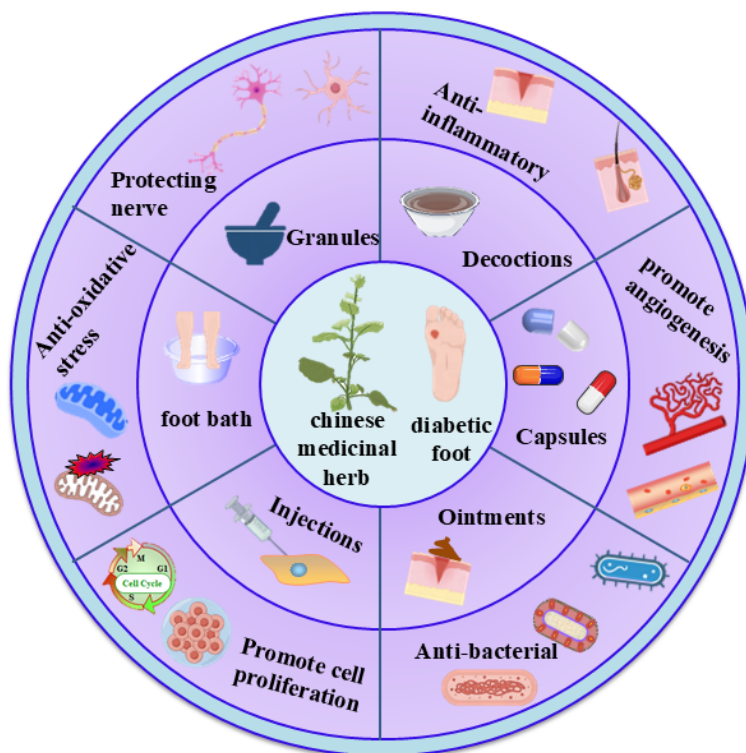


Figure 1. The mechanism of action of TCM formulations in the treatment of diabetic wounds

### 3. Granules

As a novel dosage form, TCM granules are developed based on traditional TCM decoctions and syrups. They not only inherit the advantages of decoctions, such as rapid absorption and pronounced effects, but also successfully overcome many inconveniences associated with decoctions during preparation and administration, including cumbersome decoction processes, large serving sizes, and susceptibility to mold[16]. Therefore, when treating diseases, it is often preferred to formulate the prescription into granules to better exert their therapeutic efficacy.

Experimental evidence has demonstrated that Yupingfeng Granules possess immune-enhancing, antibacterial, antiviral, and antioxidant properties. In a mouse model of atopic dermatitis, Yupingfeng Granules can regulate the numbers of CD4<sup>+</sup> and CD8<sup>+</sup> T cells, reduce the expression of AQP3 mRNA and protein, and significantly promote skin tissue repair[17]. Tangbikang (TBK) is a traditional Chinese medicine granule formulated with nine herbal ingredients. It possesses the ability to reduce oxidative stress and inflammation in vascular endothelial cells and exerts a therapeutic effect on diabetic neuropathic pain (DNP)[18]. Mudan Granules have the effects of promoting blood circulation to remove blood stasis and unblocking meridians to relieve pain, and can be used for the treatment of diabetic peripheral neuropathy. Experimental evidence has confirmed that they can reduce fasting blood glucose (FBG) and 2-hour

postprandial blood glucose (2h PBG), and enhance the conduction velocity of the median nerve, ulnar nerve, and common peroneal nerve, contributing to nerve regeneration[19]. When used in combination with growth factor gel, it demonstrates significant efficacy in the treatment of diabetic foot ulcers, possessing high clinical promotion value. After treatment, the levels of plasma C-reactive protein (CRP) and IL-1 $\beta$  decreased, while the level of IL-10 increased in both patient groups[20, 21].

### 4. Powders

Powder, also known as dusting medicine, is prepared by finely grinding medications into a powdered form and directly applying them to the affected area. This traditional Chinese medicine powder exhibits strong absorption capabilities, enabling it to rapidly absorb necrotic tissue and exudates from the wound surface. It demonstrates significant therapeutic effects, including clearing heat and detoxifying, promoting blood circulation to remove blood stasis, alleviating pain and stopping bleeding, and facilitating skin regeneration and muscle recovery[22]. Therefore, it is often used for treating diabetic foot ulcer wounds, especially those with redness, swelling, exudates, and necrotic tissue.

In a skin ulcer model of diabetic rats, treatment with Badushengji Powder significantly improved the ulcer healing rate, positive area of collagen fibers, positive rate of vascular endothelial cells, and expression of Nrf2. Meanwhile, it reduced the expression of Keap1, decreased inflammatory

cell infiltration, and increased the number of CD34-labeled neovascularizations. This suggests that Badushengji Powder promotes healing of skin ulcers in diabetic rats by enhancing collagen production, angiogenesis, inhibiting inflammation, and regulating the Keap1/Nrf2 pathway[23]. The wound tissues of rats treated with Wangshi Shengji Powder exhibited significant pathological improvements, characterized by reduced inflammatory cell infiltration, thickened epidermal layers, and increased granulation tissue, fibroblasts, and neovascularizations. Additionally, it effectively reduced the levels of TNF- $\alpha$  and CRP in serum and promoted capillary angiogenesis and fibroblast proliferation. In summary, Wangshi Shengji Powder significantly promotes wound healing in rats with perianal abscesses, and its mechanism may involve activating the HIF-1 $\alpha$ /VEGF signaling pathway, reducing inflammatory responses, and promoting angiogenesis[24].

## 5. Capsules

After treatment with Tongxinluo Capsule, the levels of nephrin, podocin, VEGF, and HIF-1 $\alpha$  were significantly increased, with a decrease in M1 macrophages and an increase in M2 macrophages, thereby promoting wound healing[25]. Shumai Capsule can increase the levels of IGF-1, EGF, and NO in patients, reduce the level of TNF- $\alpha$ , enhance nerve conduction velocity, and promote wound healing[26]. Jingmaitong (JMT) is a compound preparation consisting of 12 traditional Chinese medicines that has been used for the treatment of diabetic peripheral neuropathy (DNP) for over a decade. It effectively improves diabetic peripheral neuropathy by activating the Wnt/ $\beta$ -catenin signaling pathway[27]. Furthermore, Furong Tongmai Capsule combined with traditional Chinese medicine foot bath can significantly increase the serum level of NGF, decrease the level of IL-1 $\beta$ , reduce the dorsalis pedis artery blood flow parameters in patients with diabetic high-risk feet, lower blood viscosity, enhance nerve conduction velocity, and improve neurological function[28].

## 6. Injections

Diabetic peripheral neuropathy (DPN) is a common complication of diabetes, mainly manifested as pain, numbness, and weakness in the lower extremities, severely affecting patients' quality of life and potentially leading to diabetic foot ulcers and even amputation[29]. Currently, the treatment of neuropathy typically involves the use of drugs such as alprostadil and mecobalamin, while maintaining stable blood glucose levels. Mecobalamin, as an endogenous form of vitamin B12 and a neurotrophic agent, participates in carbon cycling and transmethylation reactions in the body. Folic acid, on the other hand, promotes the synthesis of proteins and lecithin in nerve cells, facilitates the regeneration of neuronal axons and axonal transport, and regulates nucleic acid metabolism[30]. However, commonly used western medicines such as mecobalamin and neurotrophic factors have shown limited efficacy in treating diabetic peripheral neuropathy.

According to TCM theory, diabetic peripheral neuropathy falls into the category of Xiaoke. In recent years, Chinese herbal medicines have played an increasingly important role in treating the complex pathogenesis and symptoms of diseases. The mechanism of Chinese herbal medicine in treating DPN involves protecting pancreatic cells, improving

blood glucose and lipid levels, and delaying disease progression through antioxidant therapy[31]. Studies have shown that Danhong Injection, Ginkgo Injection, and Puerarin Injection can be used as adjuvant therapies for DPN. Ginkgo biloba extract in Ginkgo Leaf Injection possesses the abilities to scavenge oxygen free radicals, regulate various antioxidant enzymes, increase local blood volume, and inhibit platelet aggregation by dilating capillaries, thereby improving microcirculation and treating DPN[32]. Puerarin is one of the flavonoid compounds extracted from the root of Pueraria lobata. Puerarin Injection, a traditional Chinese medicine, has been widely used in the treatment of angina pectoris, cardiovascular diseases, ischemic stroke, and various other conditions. Recent pharmacological studies have confirmed that Puerarin Injection can lower blood glucose levels, improve microcirculation, dilate coronary arteries, reduce platelet aggregation, and significantly enhance both sensory and motor nerve conduction velocities, thereby demonstrating certain advantages in the treatment of DPN[33].

Experimental evidence also confirms that the polyphenolic compound resveratrol (RSV) possesses significant anti-inflammatory, neuroprotective, analgesic, and antioxidant properties. In terms of wound healing promotion, both local and systemic administration of RSV can accelerate collagen deposition, facilitate granulation tissue formation, and thus advance the wound healing process. However, due to the low bioavailability of orally administered RSV, an increasing number of novel drug delivery systems are being locally applied to skin wounds. Topical dressings prepared from chitosan, sodium hyaluronate, and RSV can effectively promote skin wound healing[34].

## 7. Decoctions

Chinese herbal decoctions can dialectically regulate the imbalance of Yin and Yang within the human body, restoring their equilibrium and thereby aiding in the elimination of diseases. Xuebifang (XBF), formulated with the compatibility of Astragalus membranaceus, Cassia twig, Millelletia reticulata, Paeoniae Lactiflora Radix, Polygonum multiflorum, and Glycyrrhizae Radix et Rhizoma, has been investigated through network pharmacological studies. These studies suggest that  $\beta$ -sitosterol, formononetin, and calycosin may serve as the key active compounds in XBF. They exert therapeutic effects in diabetic neuropathic pain (DNP) primarily by targeting TNF, TLR, CLR, and NOD signaling pathways, thereby alleviating neuronal inflammatory responses and modulating immune cells[35]. Numerous animal studies and clinical trials have demonstrated that Huangqi Guizhi Wuwu Tang (HGWD) can improve neurological function and promote blood circulation by enhancing the expression of neurotrophic factors and reducing the production of peroxides[36]. In the imiquimod-induced psoriasis mouse model, Qingre Huoxue Decoction (QHD) effectively reduces the expression of angiogenic factors such as HIF-1 $\alpha$ , FLT-1, and VEGF, promotes the expression of IL-10, alleviates inflammation, and facilitates angiogenesis and tissue repair[37]. Huangqi Yanghe Decoction is capable of modulating the PI3K/AKT/NF- $\kappa$ B signaling pathway by enhancing the expression levels of TopO2 in the surrounding tissue of wounds, as well as the serum levels of VEGF, HIF-1 $\alpha$ , and p-PI3K proteins. Simultaneously, it reduces the levels of FBG, serum CRP, IL-6, and the expression of p-NF- $\kappa$ B p65 protein in wound tissue. These effects collectively suppress inflammatory responses

and promote angiogenesis, thereby facilitating wound healing[38]. Buyang Huanwu Decoction may activate the ERK signaling pathway, subsequently promoting the proliferation and migration of HaCaT cells, thereby contributing to the healing process of diabetic foot ulcers[39]. Additionally, the performance of Simiao Yong'an Decoction in diabetic foot rat models is equally remarkable. It not only significantly promotes angiogenesis and wound healing but also effectively enhances microcirculation. In-depth research indicates that this therapeutic effect may be associated with the regulation of the NGF/Akt/GSK3 $\beta$  pathway, paving new avenues and providing novel insights for the treatment of diabetic foot. For further details[40], please refer to Figure 2 and Table 1.

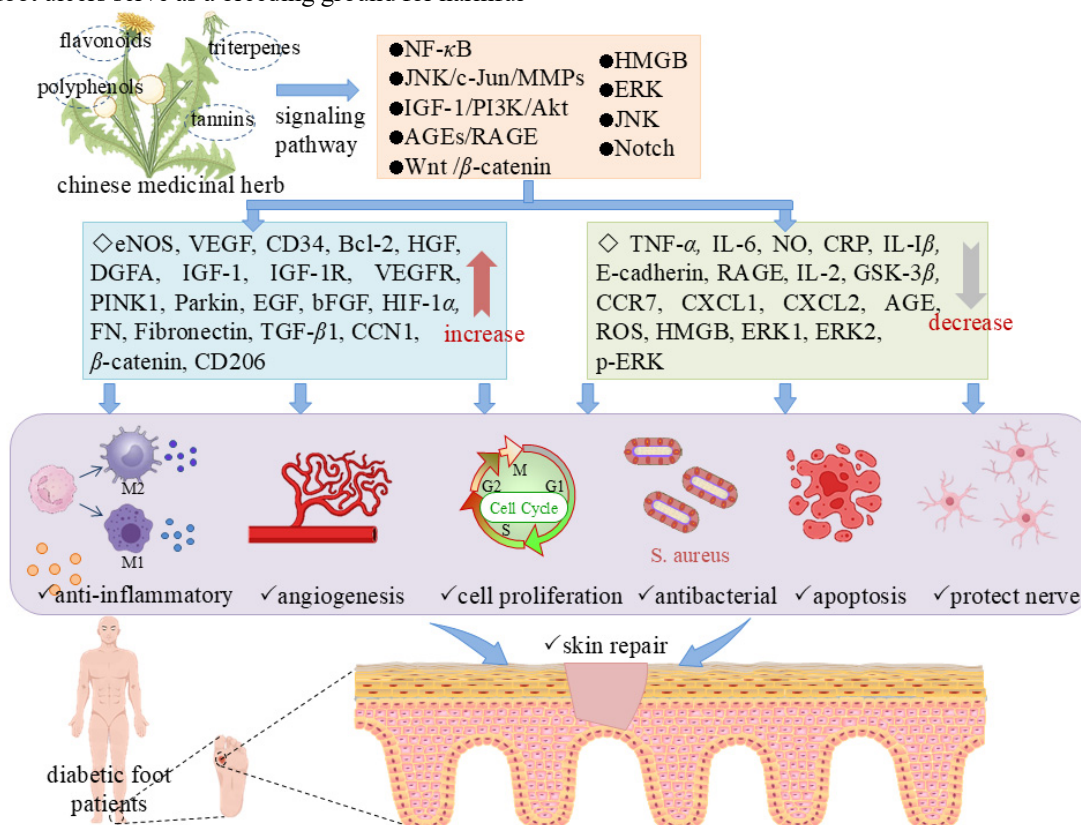
## 8. Microneedles

The skin, being the largest and most accessible organ of the human body, serves as an effective conduit for delivering various therapeutic agents. Transdermal drug delivery can be utilized for treating localized skin disorders or for penetrating into the underlying blood vessels of the dermis and subsequently entering the systemic circulation to address systemic diseases[41]. Microneedles (MNs), composed of an array of needles and a base, represent a minimally invasive and effective transdermal drug delivery system employed to enhance wound healing. Transdermal drug delivery circumvents first-pass hepatic metabolism and gastrointestinal enzymatic degradation, enabling controlled release and minimizing systemic exposure and side effects. Additionally, it can penetrate and disrupt the integrity of biological membranes, facilitating drug diffusion into infected wounds and significantly improving therapeutic outcomes[42].

Diabetic foot ulcers serve as a breeding ground for harmful

microorganisms. In a study involving 162 patients, a total of 255 different types of bacteria were detected, many of which exhibited high levels of antibiotic resistance and biofilm-forming capabilities. In medical research, Yunnan Baiyao has been proven to significantly inhibit the activity of *Pseudomonas aeruginosa*, effectively reducing the amounts of Las A protease, Las B elastase, and pyocyanin secreted by this bacterium, thereby exerting potent antibacterial effects[43]. In streptozotocin (STZ)-induced diabetic rats, Yunnan Baiyao ointment demonstrated exceptional performance in promoting the proliferation of fibroblasts and the formation of granulation tissue and angiogenesis, which facilitated the rapid recovery of diabetic skin injury wounds[44]. Experimental evidence also indicates that the prepared Yunnan Baiyao multifunctional microneedle patch, when applied to skin wounds in rats, may accelerate wound healing by enhancing fibroblast density, collagen deposition, and angiogenesis[45].

The leaves of *Premna microphylla* are rich in pectin and diverse amino acids, making them a natural nutrient treasure trove with effects of clearing heat, detoxifying, reducing swelling, and stopping bleeding. *Centella asiatica* contains asiatic acid, which possesses favorable pharmacological activities. The base layer of the microneedles (MNs) is loaded with Yunnan Baiyao and *Bletilla striata* polysaccharide, while the tips of the MNs are loaded with GelMA (gelatin methacrylate) containing epidermal growth factor (EGF). A novel herbal microneedle patch has been developed, combining the extracts of *Premna microphylla* and *Centella asiatica* with the microstructure of microneedles to promote wound healing. Experimental results demonstrate that this novel herbal microneedle can significantly promote angiogenesis, collagen formation, and granulation tissue development[46].



**Figure 2.** The mechanism of action of traditional Chinese medicine formulations in promoting diabetic wound healing

## 9. Other Dosage Forms for Treatment

Furthermore, traditional Chinese medicine fumigation therapy is frequently utilized in clinical practice for the treatment of diabetic wounds. This therapy directly targets the affected areas of patients, enabling drugs to penetrate the skin and exert their therapeutic effects internally. It accelerates blood circulation in the diseased regions and effectively promotes the improvement of clinical symptoms[47]. The silt-promoting fumigation and washing prescription is a type of herbal fumigation and washing agent, which is widely used for cleaning surgical wounds after fistula-in-ano surgery. It exhibits properties that promote wound healing and resist infection[48]. Compound Huangbai Liquid has effects such as reducing swelling and resolving necrosis, clearing heat and detoxifying, anti-inflammatory, and antibacterial properties.

Studies have shown that Compound Huangbai Liquid may promote skin ulcer healing and exert an anti-ulcer effect by inhibiting the activation of NF- $\kappa$ B-mediated inflammatory responses and promoting the expression of growth factors mediated by MAPK phosphorylation activation[49]. The modified Sanmiao coating agent can significantly promote ulcer healing in diabetic ulcer model rats, reduce the expression of IL-6, IL-1 $\beta$ , and TNF- $\alpha$ , and inhibit inflammatory responses. This may be related to the activation of the PI3K/AKT signaling pathway[50]. In addition, for grade 0 or grade 1 diabetic foot ulcers caused by neuropathy, external application, moxibustion, fumigation, acupuncture, massage, and foot bathing are alternative treatment methods. These treatments can increase blood flow in the lower extremities, regulate blood glucose and lipid metabolism, and promote neovascularization at the local wound site. [51].

**Table 1.** The effects of herbal formulas on diabetic wound

Chinese patent drug	model	route of administration	result	signaling pathways	references
Huiyang Shengji Ointment	Diabetic rat skin ulcer model; endothelial cell	medicine for external use	eNOS, VEGF $\uparrow$ ; TNF- $\alpha$ , IL-6 $\downarrow$	-	[52]
Zizhu ointment	Diabetic foot ulcer model	medicine for external use	NO, CRP, IL-6 $\downarrow$ ; VEGF, CD34 $\uparrow$	NF- $\kappa$ B, JNK and PI3K signaling pathways	[53]
Fuyuan Tongluo decoction	Diabetic foot ulcer model	intra-gastric gavage	IL-1 $\beta$ , IL-6, TNF- $\alpha$ $\downarrow$ ; Bcl-2, VEGF, HGF, DGFA $\uparrow$	-	[54]
Luohua Zizhu granules	Diabetic foot ulcer model	intra-gastric gavage	IGF-1, IGF-1R, eNOS, VEGF, VEGFR2 $\uparrow$	IGF-1/PI3K/Akt signaling pathway	[55]
Danhuangsan	Diabetic foot ulcer model	medicine for external use	PINK1, Parkin, VEGF, EGF, bFGF $\uparrow$	-	[56]
Shengji Yuhong Ointment	Diabetic foot ulcer model	medicine for external use	bFGF, HIF-1 $\alpha$ , VEGF $\uparrow$	-	[57]
Rubber myogenic cream	Diabetic foot ulcer model	medicine for external use	Fibronectin, TGF- $\beta$ 1, IGF-1, FN $\uparrow$ ; E-cadherin $\downarrow$	-	[58]
Danhuang Anti-inflammatory Juice	Diabetic rat skin ulcer model	medicine for external use	TGF- $\beta$ 1, Twist1, Clusterin $\uparrow$	-	[59]
Foot-ulcer-cure Ointment	Diabetic rat skin ulcer model	medicine for external use	RAGE $\downarrow$ , VEGF $\uparrow$	AGEs/RAGE/NF- $\kappa$ B p65 signaling pathway	[60]
Danggui blood-supplementing decoction	Diabetic foot ulcer model	intra-gastric gavage	TNF- $\alpha$ , IL-6, IL-1 $\beta$ $\downarrow$ ; VEGF $\uparrow$	-	[61]
Shengji Xiangpi Ointment	Diabetic foot ulcer model	medicine for external use	IL-2, IL-6, TNF- $\alpha$ $\downarrow$	Notch signaling pathway	[62]
Jiedu Shengji ointment	Diabetic rat skin ulcer model	medicine for external use	-	-	[63]
Simiao Yong'an Decoction	Diabetic foot ulcer model	intra-gastric gavage	$\beta$ -catenin $\uparrow$ ; GSK-3 $\beta$ $\downarrow$	Wnt/ $\beta$ -catenin signaling pathway	[64]
Qizhi jiangtang capsule	Diabetic rat skin ulcer model	intra-gastric gavage	VEGF $\uparrow$ ; p-ERK $\downarrow$	-	[65]
Heart failure capsule	Diabetic rat skin ulcer model	intra-gastric gavage	CCR7, CXCL1, CXCL2 $\downarrow$ ; CD206, p-STAT3, p-STAT6 $\uparrow$	-	[66]
Sheng-ji Hua-yu ointment	HaCaT cells	-	CCN1 $\uparrow$	-	[67]
Jingwanhong Ointment	Diabetic rat skin ulcer model	medicine for external use	AGE, RAGE, HMGB, ERK1, ERK2 $\downarrow$	HMGB and ERK signaling pathways	[68]
Compound Phellodendron liquid	Diabetic foot ulcer model	medicine for external use	TNF- $\alpha$ , IL-1 $\beta$ , IL-6 $\downarrow$ ; VEGF, EGF $\uparrow$	-	[69]
Astragalus injection	Diabetic rat skin ulcer model	intra-gastric gavage	Wnt1, Wnt3a, $\beta$ -catenin, C-myc, Cyclin D1 $\uparrow$	Wnt/ $\beta$ -catenin signaling pathway	[70]
Shengji Huayu formula	HaCaT cells	-	ROS $\downarrow$	JNK/c-Jun/MMPs signaling pathway	[71]

## 10. Conclusion and Future Perspectives

The healing process of diabetic wounds is highly complex, with multiple factors such as hyperglycemia, neuropathy, blood supply, and microbiota playing pivotal roles in the intricate cascade of diabetic wound repair. TCM has been demonstrated to possess diverse pharmacological effects and can modulate numerous biological processes, including hyperglycemia, inflammation, oxidative stress, and angiogenesis, thereby exerting positive influences on wound healing [72, 73]. Modern pharmacological research has confirmed that certain flavonoid compounds found in TCM, such as quercetin, hesperidin, curcumin, kaempferol, and luteolin, exhibit potent antibacterial activity, reduce the expression of inflammatory cytokines, enhance the expression of anti-inflammatory cytokines, mitigate insulin resistance, stimulate angiogenesis, regulate cytokines, and control blood glucose levels, thereby demonstrating significant potential in promoting wound healing[74].

Due to the intricate pathogenesis of diabetic ulcers, single or dual substances are insufficient to promote wound healing. Therefore, exploring the synergistic effects of multiple substances to accelerate the healing process of diabetic wounds has become a focal point of current research. The future direction of development may lie in the development of novel biomaterials and TCM compounds with multiple functions that can regulate wound healing at various stages. For the treatment of diabetic wounds, personalized treatment plans must be formulated based on the specific conditions of each patient. In the field of TCM, the principle of syndrome differentiation and treatment is followed to precisely select corresponding TCM prescriptions, aiming to provide patients with precision treatment services. Meanwhile, combining external treatment methods makes the entire treatment process more convenient and intuitive. In clinical practice, the treatment strategy of integrating traditional Chinese and Western medicine is advocated, with the integrated use of multiple medical means to achieve better treatment outcomes. This comprehensive treatment model can not only fully leverage the respective advantages of traditional Chinese and Western medicine but also provide patients with comprehensive and precise treatment services. However, the composition and mechanism of action of TCM remain unclear, which limits the large-scale application of TCM in clinical treatment to some extent. Existing studies have shown that natural plant active ingredients play a significant role in the healing of diabetic wounds. However, most studies focus on macroscopic-level analyses such as promoting granulation tissue regeneration, re-epithelialization, angiogenesis, and collagen deposition, lacking further in-depth exploration at the cellular and molecular levels. To enhance the therapeutic effects of Chinese herbs, loading them onto advanced wound dressings such as hydrogels, hydrophilic colloids, scaffolds, and nanofibers has emerged as a new treatment option.

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