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The Role of Traditional Chinese Medicine Therapies in Intervertebral Disc Degeneration

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Abstract: ***Intervertebral disc degeneration (IVDD) is one of the leading causes of chronic low back pain worldwide. Its onset and progression involve multiple pathological processes, including inflammatory activation, oxidative stress, ferroptosis, cellular senescence, extracellular matrix degradation, biomechanical imbalance, and endplate microcirculation dysfunction. Traditional Chinese medicine (TCM) therapies—such as acupuncture, Tuina (spinal manipulation), external herbal application, fumigation, and thermal therapy—have a long history of use in musculoskeletal disorders. Increasing modern evidence indicates that these interventions can delay IVDD progression by suppressing the NLRP3 inflammasome, modulating NF-κB activity, alleviating Piezo1-mediated mechanotransduction, and activating the Nrf2–HO-1 antioxidant pathway, thereby providing a solid biological basis for their therapeutic effects. This review systematically summarizes the modern mechanisms, experimental findings, and clinical evidence supporting acupuncture, Tuina, and external herbal therapies in IVDD, highlighting their potential as disease-modifying treatments. Furthermore, by integrating insights from multi-omics technologies and extracellular vesicles (EVs), this review explores future directions for combining TCM-based interventions with regenerative medicine.***

Keywords: Intervertebral disc degeneration, Acupuncture, Tuina (spinal manipulation), External herbal therapy, Ferroptosis, Mechanotransduction, NLRP3 inflammasome, Piezo1.

1. Introduction

Intervertebral disc degeneration (IVDD) is a highly prevalent condition in modern society, closely associated with aging, sedentary behavior, chronic mechanical loading, and lifestyle factors. As a major contributor to chronic low back pain (LBP), IVDD affects an estimated 540 million people worldwide and imposes a substantial socioeconomic burden. Current clinical treatments—such as nonsteroidal anti-inflammatory drugs (NSAIDs), muscle relaxants, and corticosteroids—primarily provide symptomatic relief but fail to halt or reverse the degenerative process. Minimally invasive interventions, including radiofrequency ablation, ozone therapy, and platelet-rich plasma (PRP) injections, may offer temporary improvement, yet their long-term efficacy remains inconsistent.

In contrast, traditional Chinese medicine (TCM) therapies are characterized by multi-target, multi-pathway, and holistic regulation, enabling them to modulate inflammation, biomechanical imbalance, neuromuscular function, and soft-tissue repair. These therapeutic features align closely with the multifactorial pathophysiology of IVDD. With advances in modern biomedical research, the underlying molecular mechanisms of acupuncture, Tuina (spinal manipulation), and external herbal therapies have been progressively elucidated, supporting their integration into evidence-based practice.

This review synthesizes recent findings from basic studies and clinical evidence to comprehensively summarize the mechanistic foundations and therapeutic potential of TCM-based interventions in IVDD. In addition, it offers perspectives on future directions for the development and integration of these therapies.

2. Pathological Mechanisms of Intervertebral Disc Degeneration

The intervertebral disc is composed of the nucleus pulposus, annulus fibrosus, and cartilaginous endplate [1]. Under physiological conditions, disc homeostasis is maintained through a highly hydrated proteoglycan-rich matrix, an organized collagen fiber network, and a stable nutrient supply delivered via diffusion through the endplate. However, with advancing age, sedentary lifestyle, repetitive bending or heavy loading, and cumulative acute or chronic injuries, disc cellular homeostasis becomes progressively disrupted, accompanied by significant alterations in the local microenvironment. Persistent inflammatory activation, increased oxidative stress, abnormal biomechanical loading, and impaired endplate nutrient transport synergistically contribute to the degenerative cascade, ultimately reducing the disc's elasticity and load-bearing capacity.

Inflammation often emerges as an early and amplifying event in IVDD. When nucleus pulposus cells are exposed to abnormal mechanical compression, acidic pH, or oxidative injury, they rapidly release pro-inflammatory mediators such as IL-1β, TNF-α, IL-6, and IL-8 [2]. These cytokines activate the NF-κB signaling pathway, leading to excessive expression of matrix-degrading enzymes, including MMP3 and MMP13, which accelerate extracellular matrix (ECM) breakdown, loosen annular structure, and further damage disc integrity [3].At the same time, the NLRP3 inflammasome becomes highly activated in degenerated discs; downstream caspase-1 activation promotes maturation and release of IL-1β and IL-18, fueling a vicious inflammatory cycle and inducing pyroptosis, thereby worsening disc degeneration [4].

Beyond inflammation, oxidative stress and ferroptosis have

gained increasing attention as key contributors to IVDD. Due to its avascular nature, the intervertebral disc is particularly vulnerable to oxidative injury. When reactive oxygen species (ROS) accumulate beyond the capacity of intrinsic antioxidant defenses, mitochondrial dysfunction, enhanced lipid peroxidation, and DNA damage inevitably promote cellular senescence and death [5]. More critically, downregulation of GPX4 and SLC7A11 triggers a classical ferroptotic phenotype, rendering nucleus pulposus cells highly susceptible to lipid peroxidation stress and significantly impairing their ECM synthetic capacity [6].

Mechanical stress is another major driving factor. Chronic poor posture, repetitive lumbar loading, and weakened core musculature disrupt normal spinal biomechanics, leading to sustained activation of mechanosensitive ion channels such as Piezo1 [7]. Excessive Piezo1-mediated Ca^{2+} influx suppresses ECM synthesis and activates inflammatory signaling pathways including NF-κB and MAPK, thereby reinforcing the reciprocal amplification between mechanical overload and inflammation and forming a vicious cycle of mechanical stress–inflammation–cellular injury [8]. Moreover, calcification and microfissures in the cartilaginous endplate impede nutrient diffusion, creating prolonged hypoxic and acidic conditions that further aggravate cellular dysfunction and matrix degeneration [9].

From the perspective of traditional Chinese medicine (TCM), these pathological alterations align closely with concepts such as "Qi and blood stasis," "meridian obstruction," and "kidney essence deficiency," providing a theoretical correspondence between TCM and modern biomedical understanding and supporting the rationale for applying TCM-based interventions in IVDD [10].

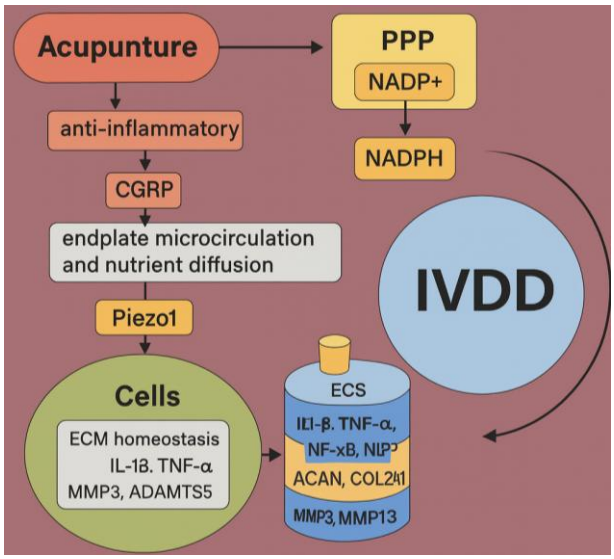

Figure 1: This schematic summarizes the multi-level regulatory effects of acupuncture, manual therapy, and herbal external treatments on degenerative intervertebral discs.

Notes: These interventions modulate inflammatory signaling (IL-1β, TNF-α, NF-κB, NLRP3), reduce oxidative stress and ferroptosis (ROS, GPX4, SLC7A11), improve endplate microcirculation and nutrient diffusion, and restore biomechanical balance by reducing abnormal mechanical loading mediated by Piezo1 activation. TCM therapies further promote extracellular matrix (ECM) homeostasis by enhancing the synthesis of ACAN and COL2A1 while inhibiting MMP3, MMP13, and ADAMTS5. Together, these integrated biological effects help maintain disc cell viability, improve metabolic stability, and slow IVDD progression

3. Traditional Chinese Medicine (TCM) Perspectives on Intervertebral Disc Degeneration

TCM, grounded in holistic concepts and systemic regulation, views spinal health as the result of coordinated interactions among the internal organs, meridian circulation, Qi–blood dynamics, and constitutional balance [11]. Within this theoretical framework, the principle that "the kidney governs bones and generates marrow" provides an essential foundation for understanding disc degeneration. Adequate kidney essence is believed to nourish the bones and tendons, thereby maintaining spinal stability; conversely, deficiency of kidney essence leads to weakened osseous structures and impaired tendon nourishment—an interpretation that parallels modern biomedical findings of reduced nucleus pulposus cell function and diminished extracellular matrix (ECM) synthesis during IVDD.

Moreover, the TCM concept of "Qi and blood deficiency" is regarded as a fundamental cause of impaired tissue repair. This aligns with contemporary evidence showing that compromised microcirculation of the cartilaginous endplate—and the resulting insufficient diffusion of glucose and oxygen—is a key driver of metabolic dysfunction in nucleus pulposus cells [12]. The notion of "phlegm-dampness and stasis obstruction" in TCM can be mapped onto modern pathological features such as the accumulation of inflammatory mediators, disturbances in lipid metabolism, and buildup of acidic metabolic by-products that contribute to a toxic microenvironment. Similarly, the TCM concept of "blood stasis obstructing the channels," characterized by impaired circulation and aggravated pain, closely corresponds to biomedical mechanisms involving microvascular insufficiency, neuronal sensitization, and chronic pain [13].

Thus, although TCM theories originate from macro-level observations of life processes, their pathological descriptions reveal substantial parallels with modern biomedical understanding of IVDD. These conceptual correspondences provide a coherent theoretical basis for integrating TCM therapeutic approaches into the management of intervertebral disc degeneration.

4. Integrated Mechanisms of Traditional Chinese Medicine Therapies

Traditional Chinese medicine (TCM) interventions for intervertebral disc degeneration primarily include acupuncture, Tuina (spinal manipulation), and external herbal therapies [14]. A defining feature of these modalities is their multi-target, multi-system, and multi-level synergistic actions, enabling them to address the complex and multifactorial pathology of disc degeneration. In clinical practice, these therapies are often used in combination, providing not only symptomatic relief but also improvements in deeper tissue structures and cellular functions [15].

Acupuncture modulates neural activity, immune responses, and local blood flow by stimulating specific acupoints, exerting both localized effects and systemic regulation through neuro–immune–endocrine pathways [16]. Tuina and

spinal manipulation primarily act through biomechanical mechanisms—adjusting facet joint alignment, relaxing hypertonic musculature, and restoring spinal mechanical balance—to optimize disc loading conditions and attenuate abnormal activation of mechanosensitive channels such as Piezo1 [17]. External herbal therapies, including topical application, fumigation, and thermal treatments, rely on transdermal absorption and thermal stimulation to enhance local microcirculation, reduce inflammation and oxidative stress, and promote extracellular matrix (ECM) repair in paraspinal tissues [18].

Collectively, these three therapeutic modalities have been shown to modulate core pathological processes of IVDD, including inflammatory responses, mechanical stress, oxidative injury, and neural sensitization. By improving ECM synthesis, cellular metabolic activity, and the overall microenvironment from multiple dimensions, integrated TCM therapies represent an important and effective strategy for managing intervertebral disc degeneration.

5. The Role of Acupuncture in Intervertebral Disc Degeneration

As one of the most representative therapeutic modalities in traditional Chinese medicine, acupuncture plays a multifaceted role in the management of intervertebral disc degeneration (IVDD). Beyond its well-recognized effects in alleviating pain and improving mobility, modern studies have increasingly demonstrated that acupuncture functions as a comprehensive intervention capable of modulating the cellular microenvironment, suppressing inflammatory responses, and promoting tissue repair.

A primary mechanism underlying acupuncture's therapeutic effect in IVDD is its potent anti-inflammatory action. Evidence shows that manual acupuncture and electroacupuncture can downregulate the activity of the NLRP3 inflammasome, reduce the maturation and release of pro-inflammatory cytokines such as IL-1β and IL-18, and inhibit the nuclear translocation of NF-κB. These effects collectively prevent the excessive propagation of inflammation toward ECM-degrading pathways. Consequently, the expression of matrix-degrading enzymes, including MMP3 and MMP13, is reduced, thereby mitigating disc matrix destruction [19].

In addition to regulating inflammation, acupuncture significantly improves local microcirculation. Because the intervertebral disc lacks direct blood supply and depends entirely on nutrient diffusion through the cartilaginous endplate, enhancing endplate perfusion is critical for maintaining disc cell metabolism. Studies have shown that acupuncture at acupoints such as Yaoyangguan (GV3) and Shenshu (BL23) markedly increases regional blood flow, improves oxygen delivery, and promotes the clearance of metabolic by-products—all of which help restore ECM synthesis and reduce apoptosis of disc cells [20].

Acupuncture also plays an essential role in modulating neural activity and reducing pain sensitization. Clinical evidence indicates that acupuncture can decrease levels of pain-related neuropeptides such as CGRP and substance P at peripheral nerve terminals and suppress aberrant neuronal firing in the spinal dorsal horn, thereby alleviating persistent pain. Meanwhile, electroacupuncture promotes the release of endogenous opioids such as β-endorphin, which not only improves pain perception but also relaxes paraspinal musculature and reduces aberrant loading on the intervertebral disc.

The acupoint-specific effects of acupuncture further enhance its therapeutic value. Commonly used lumbar acupoints are located across the L2–L5 segments, which correspond precisely to the regions where disc degeneration frequently occurs. Stimulation of these sites modulates sympathetic–parasympathetic balance and improves the condition of local soft tissues surrounding the spine. Thus, whether through localized tissue modulation or systemic neuro-immune regulation, acupuncture offers unique therapeutic advantages in IVDD, with its underlying mechanisms increasingly supported by modern scientific evidence [21].

6. Biomechanical and Molecular Mechanisms of Tuina and Spinal Manipulation

Tuina and spinal manipulation play an irreplaceable role in the treatment of intervertebral disc degeneration, primarily by restoring the biomechanical environment of the spine. As a structure highly dependent on mechanical stability, the intervertebral disc is profoundly influenced by factors such as intradiscal pressure distribution, facet joint alignment, and the tension of paraspinal muscles. By releasing soft-tissue adhesions, adjusting joint positions, and restoring segmental mobility, Tuina can fundamentally correct biomechanical deviations caused by chronic poor posture or repetitive loading, thereby redistributing spinal forces more physiologically [22].

Modern research has revealed that the biomechanical benefits of Tuina extend far beyond simple structural realignment. Prolonged abnormal mechanical stimulation can lead to sustained activation of the mechanosensitive ion channel Piezo1, resulting in excessive Ca^{2+} influx and subsequent apoptosis and inflammation in nucleus pulposus (NP) cells. By improving posture and restoring segmental mechanics, Tuina reduces shear and compressive loads on the disc, thereby lowering Piezo1 activation and helping to reestablish intracellular calcium homeostasis. This reduction in mechanical stress–induced signaling also dampens downstream inflammatory responses. Furthermore, Tuina has been shown to regulate the Integrin–FAK–ERK signaling pathway, a critical cascade governing ECM synthesis and cell adhesion. As a result, Tuina not only corrects biomechanical abnormalities but also promotes ECM repair and matrix regeneration at the molecular level [23].

In addition, Tuina positively influences nutrient transport through the cartilaginous endplate, which is the essential diffusion pathway for disc nutrition. Because endplate permeability is strongly affected by mechanical conditions, restoring healthy segmental motion can significantly improve endplate microcirculation and diffusion capacity. Findings from MRI T2 mapping studies have demonstrated increased disc water content following Tuina intervention, suggesting that this therapy may partially reverse early metabolic

impairment in degenerating discs [24].

Tuina also exerts beneficial effects through neuromuscular regulation. Joint mobilization decreases excessive sympathetic activation, enhances local blood flow, and relaxes hypertonic muscles, enabling them to regain proper stabilizing function. Through this combined modulation of soft tissue and neural pathways, Tuina and spinal manipulation play a valuable role in the long-term management of IVDD. Beyond relieving pain and improving functional disability, they may further slow disc degeneration by optimizing the biomechanical environment and promoting healthier cellular behavior [25].

7. Modern Mechanisms of External Herbal Therapy, Fumigation, and Thermal Treatments

External herbal therapies, fumigation, and thermal treatments are widely used in the management of intervertebral disc degeneration (IVDD), owing to their traditional characteristics of "directly targeting the diseased region" and "warming and unblocking the meridians." Modern research has progressively elucidated their scientific foundations, revealing regulatory effects on local blood flow, inflammation, oxidative stress defense, and neural modulation.

First, thermally based external therapies—such as herbal fumigation and hot compresses—can significantly dilate local capillaries, increase blood perfusion in the skin and deeper soft tissues, and enhance metabolic activity in the paraspinal fascia, ligaments, and muscles. Heating also increases skin permeability, allowing active herbal compounds to penetrate more efficiently through the skin barrier and accumulate in the targeted tissues, thereby providing a material basis for local pharmacological effects.

At the molecular level, external herbal applications and fumigation activate the Nrf2–HO-1 antioxidant pathway, enhancing the ability of local cells to scavenge reactive oxygen species (ROS), reducing lipid peroxidation, and improving oxidative stress status—an effect particularly important for mitigating ferroptosis. Additionally, bioactive components of herbal medicines inhibit inflammatory mediators such as COX-2 and PGE2, and suppress the expression of matrix-degrading enzymes including MMP3 and MMP13, contributing to the preservation of extracellular matrix (ECM) stability and structural integrity [26].

In terms of pain management, external herbal therapy exerts thermal stimulation that activates TRPV1/3 channels, improves local blood circulation, and modulates neural reflexes. Meanwhile, certain herbal constituents regulate the release of pain mediators and elevate pain thresholds. These combined actions not only alleviate pain but also help reduce muscle spasm and soft-tissue tension, ultimately enhancing the overall biomechanical environment surrounding the intervertebral disc.

Taken together, external herbal therapy, fumigation, and thermal interventions exert their therapeutic effects through a synergistic combination of thermal effects, pharmacological effects, and meridian modulation. By targeting multiple pathological mechanisms—including inflammation, oxidative stress, mechanical abnormalities, and metabolic dysfunction—these interventions represent important components of comprehensive TCM-based treatment strategies for IVDD [27].

8. Clinical Studies and Evidence-Based Support

With ongoing advances in basic research, the clinical value of traditional Chinese medicine (TCM) therapies in patients with intervertebral disc degeneration (IVDD) has increasingly been supported by evidence-based medicine. Multicenter randomized controlled trials of acupuncture have demonstrated that it provides significantly greater reductions in pain severity (VAS) and improvements in functional disability (ODI) compared with conventional control treatments. Some studies further report that acupuncture enhances the electrophysiological function of paraspinal muscles and improves muscular coordination, thereby contributing to more sustained structural and functional benefits [28].

Evidence supporting Tuina therapy is also accumulating. Systematic reviews indicate that Tuina can rapidly relieve acute pain and exert long-term therapeutic effects on chronic low back pain. Specific Tuina protocols have been shown to improve segmental mobility and reduce recurrence rates by modulating spinal biomechanics. In clinical practice, Tuina combined with therapeutic exercise—such as corrective gymnastics, core stabilization training, and functional rehabilitation—is often considered more effective, as it helps maintain spinal stability and sustain a healthy biomechanical state of the intervertebral disc.

Clinical studies of external herbal therapies likewise demonstrate clear benefits for chronic low back pain. Herbal fumigation and thermal applications can reduce muscle stiffness, improve local inflammatory markers, and enhance patients' daily functional capacity and quality of life. Compared with oral medications, external therapies offer stronger localized effects and fewer systemic side effects, making them particularly suitable for individuals with chronic or recurrent pain.

Despite generally favorable findings, current clinical research faces limitations, including small sample sizes, short follow-up durations, and heterogeneous outcome measures. Future progress requires more high-quality, multicenter, rigorously designed randomized controlled trials to further validate the disease-modifying potential of TCM-based therapies in IVDD.

9. Limitations and Future Perspectives

Although traditional Chinese medicine (TCM) therapies demonstrate the advantages of multi-target modulation, low side-effect profiles, and holistic regulation in the management of intervertebral disc degeneration (IVDD), several challenges still hinder their research advancement and broader international adoption. First, the lack of standardized operational protocols remains a major bottleneck. Considerable variability exists among practitioners and

studies regarding acupuncture point selection, stimulation parameters, and electroacupuncture frequency; manipulation force, direction, and rhythm in Tuina therapy; as well as herbal composition, dosage, temperature, and treatment duration in external therapies. These inconsistencies not only influence therapeutic outcomes but also limit comparability and reproducibility across studies.

Second, current clinical research is often constrained by small sample sizes, difficulty implementing double-blind designs, and short follow-up durations, resulting in evidence that is suggestive but not yet definitive. At the basic research level, most existing models rely on single-factor induction, which fails to capture the multifactorial nature of IVDD involving intertwined mechanical stress, inflammation, and oxidative injury. Furthermore, the transdermal absorption dynamics and deep-tissue distribution of external herbal medicines remain insufficiently characterized, limiting the mechanistic understanding of their therapeutic effects.

Looking ahead, the development of TCM therapies requires coordinated advancements across multiple domains. Establishing standardized and quantifiable intervention systems—such as intelligent acupuncture devices, biomechanical feedback–based Tuina equipment, and temperature-controlled herbal fumigation platforms—may significantly enhance reproducibility. Integrating multi-omics technologies to map the molecular networks influenced by TCM interventions will help generate high-resolution mechanistic evidence. Moreover, combining TCM therapies with regenerative medicine, including herbal compound–loaded extracellular vesicles (EVs) and herbal extract–based hydrogel biomaterials, holds promising potential as innovative strategies for disc repair and regeneration [29].

Ultimately, through improving evidence quality, deepening mechanistic research, and advancing technical standardization, TCM-based interventions may evolve from adjunctive treatments into true disease-modifying therapies (DMTs) and become an indispensable component of global spinal health management.

10. Conclusion

Intervertebral disc degeneration (IVDD), a principal cause of chronic low back pain, involves multiple pathological processes, including inflammatory activation, oxidative stress, abnormal mechanical loading, metabolic dysregulation, neural sensitization, and microcirculatory impairment. Although modern medicine has made substantial progress in elucidating these mechanisms, effective approaches capable of reversing disc degeneration or promoting true disc regeneration remain limited. In this context, traditional Chinese medicine (TCM) therapies—characterized by their multi-target, systemic, and holistic regulatory properties—are emerging as promising complementary strategies for the comprehensive management of IVDD.

Acupuncture, Tuina (spinal manipulation), and external herbal therapies not only improve pain and functional impairment at the symptomatic level but also modulate the internal disc microenvironment through multiple mechanisms. These include restoring biomechanical balance, enhancing endplate diffusion, promoting extracellular matrix (ECM) synthesis, and suppressing inflammation and apoptosis. Specifically, acupuncture mitigates inflammatory cascades through neuro–immune modulation; Tuina reduces Piezo1-mediated mechanical injury by reshaping spinal biomechanics; and external herbal therapies alleviate oxidative stress and ferroptosis by enhancing transdermal drug delivery and activating the Nrf2–HO-1 antioxidant pathway. Collectively, these mechanistic insights provide a modern scientific foundation for TCM interventions and support their shift from empirical treatments to mechanisms-based, integrative therapeutic strategies [30].

Despite encouraging clinical outcomes, several challenges persist, including insufficient standardization, limited evidence quality, and insufficient depth of mechanistic research. Future studies require more rigorous experimental designs, larger clinical cohorts, and longer follow-up periods. With advances in multi-omics, single-cell sequencing, high-resolution imaging, and biomaterials science, the cellular and molecular mechanisms of acupuncture, Tuina, and external herbal therapies will become increasingly clear. Furthermore, the integration of TCM with wearable technologies, digital therapeutic systems, intelligent acupuncture platforms, and biomechanical monitoring tools will accelerate the transition toward more precise and objective treatment modalities.

As regenerative medicine and tissue engineering continue to evolve, the combination of TCM therapies with modern technologies may yield major breakthroughs. For example, coupling herbal bioactive compounds with extracellular vesicle (EV) carriers may enhance targeting and stability, herbal-based hydrogels may improve local drug delivery efficiency, and integrating mechanical stimulation with regenerative strategies may further optimize the disc microenvironment. These interdisciplinary approaches hold great promise for the long-term management of IVDD.

Overall, the therapeutic value of traditional Chinese medicine in IVDD is increasingly supported by emerging research. With its holistic perspective and multi-pathway regulatory capabilities, TCM not only provides symptomatic relief but also possesses potential disease-modifying effects. As research continues to deepen and technological innovations advance, TCM-based therapies are expected to play an increasingly important role in global spine health management and may become a driving force in reshaping future paradigms for IVDD treatment.

References

[1] Cachot, U., et al., A multiscale finite element model of fluid-microstructure interactions in human intervertebral disc compression. Acta Biomater, 2025. 207: p. 398-413.
[2] Sun, H., et al., Excessive compression induces cartilage endplate degeneration via the Piezo1/NAT10/mTOR signaling axis. Osteoarthritis Cartilage, 2025.
[3] Risbud, M.V. and I.M. Shapiro, Role of cytokines in intervertebral disc degeneration: pain and disc content. Nat Rev Rheumatol, 2014. 10(1): p. 44-56.

[4] Chen, Z.H., et al., Enhanced NLRP3, caspase-1, and IL-1β levels in degenerate human intervertebral disc and their association with the grades of disc degeneration. Anat Rec (Hoboken), 2015. 298(4): p. 720-6.
[5] Cao, G., et al., The Role of Oxidative Stress in Intervertebral Disc Degeneration. Oxid Med Cell Longev, 2022. 2022: p. 2166817.
[6] Fan, C., et al., The role of ferroptosis in intervertebral disc degeneration. Front Cell Dev Biol, 2023. 11: p. 1219840.
[7] Liu, C., et al., Aberrant mechanical loading induces annulus fibrosus cells apoptosis in intervertebral disc degeneration via mechanosensitive ion channel Piezo1. Arthritis Res Ther, 2023. 25(1): p. 117.
[8] Wu, J., et al., Self-amplifying loop of NF-κB and periostin initiated by PIEZO1 accelerates mechano - induced senescence of nucleus pulposus cells and intervertebral disc degeneration. Mol Ther, 2022. 30(10): p. 3241-3256.
[9] Kuchynsky, K., et al., Transcriptional profiling of human cartilage endplate cells identifies novel genes and cell clusters underlying degenerated and non-degenerated phenotypes. Arthritis Res Ther, 2024. 26(1): p. 12.
[10] Wang, S.J., et al., Mechanism of Treatment of Kidney Deficiency and Osteoporosis is Similar by Traditional Chinese Medicine. Curr Pharm Des, 2016. 22(3): p. 312-20.
[11] Li, S. and B. Zhang, Traditional Chinese medicine network pharmacology: theory, methodology and application. Chin J Nat Med, 2013. 11(2): p. 110-20.
[12] Galbusera, F., M. Brayda-Bruno, and H.J. Wilke, Is post-contrast MRI a valuable method for the study of the nutrition of the intervertebral disc? J Biomech, 2014. 47(12): p. 3028-34.
[13] Wang, X., et al., The association between genetic risk and traditional Chinese medicine syndromes in T2DM patients: A latent class analysis. Medicine (Baltimore), 2025. 104(32): p. e42424.
[14] Zhang, B., et al., A narrative review of non-operative treatment, especially traditional Chinese medicine therapy, for lumbar intervertebral disc herniation. Biosci Trends, 2017. 11(4): p. 406-417.
[15] Zhu, L., et al., The treatment of intervertebral disc degeneration using Traditional Chinese Medicine. J Ethnopharmacol, 2020. 263: p. 113117.
[16] Lim, T.K., et al., Acupuncture and Neural Mechanism in the Management of Low Back Pain-An Update. Medicines (Basel), 2018. 5(3).
[17] Yang, M., et al., Effectiveness of Chinese massage therapy (Tui Na) for chronic low back pain: study protocol for a randomized controlled trial. Trials, 2014. 15: p. 418.
[18] Sun, C., et al., Effect of Baimai ointment on lumbar disc herniation: A multicentre, prospective, randomised, double-blind, placebo-controlled trial. Phytomedicine, 2024. 122: p. 155138.
[19] Wang, M., et al., Electroacupuncture attenuates intervertebral disc degeneration by upregulating aquaporins via the cAMP/PKA pathway. J Orthop Surg Res, 2025. 20(1): p. 310.
[20] De Geer, C.M., Intervertebral Disk Nutrients and Transport Mechanisms in Relation to Disk Degeneration: A Narrative Literature Review. J Chiropr Med, 2018. 17(2): p. 97-105.
[21] Wang, Y.L., et al., Electroacupuncture Zusanli (ST36) Relieves Somatic Pain in Colitis Rats by Inhibiting Dorsal Root Ganglion Sympathetic-Sensory Coupling and Neurogenic Inflammation. Neural Plast, 2023. 2023: p. 9303419.
[22] Vergroesen, P.P., et al., Mechanics and biology in intervertebral disc degeneration: a vicious circle. Osteoarthritis Cartilage, 2015. 23(7): p. 1057-70.
[23] Shi, S., et al., Excessive mechanical stress-induced intervertebral disc degeneration is related to Piezo1 overexpression triggering the imbalance of autophagy/apoptosis in human nucleus pulpous. Arthritis Res Ther, 2022. 24(1): p. 119.
[24] Thiry, P., et al., Short-term increase in discs' apparent diffusion is associated with pain and mobility improvements after spinal mobilization for low back pain. Sci Rep, 2018. 8(1): p. 8281.
[25] Amoroso Borges, B.L., G.L. Bortolazzo, and H.P. Neto, Effects of spinal manipulation and myofascial techniques on heart rate variability: A systematic review. J Bodyw Mov Ther, 2018. 22(1): p. 203-208.
[26] Peng, Y., et al., Anti-Inflammatory Effects of Curcumin in the Inflammatory Diseases: Status, Limitations and Countermeasures. Drug Des Devel Ther, 2021. 15: p. 4503-4525.
[27] Yan, S., et al., Regulation of transient receptor potential channels by traditional Chinese medicines and their active ingredients. Front Pharmacol, 2022. 13: p. 1039412.
[28] Yan, L., et al., Efficacy of acupuncture for lumbar disc herniation: changes in paravertebral muscle and fat infiltration - a multicenter retrospective cohort study. Front Endocrinol (Lausanne), 2024. 15: p. 1467769.
[29] Guan, J., et al., Traditional Chinese medicine for treating aplastic anemia. J Pharm Pharm Sci, 2023. 26: p. 11863.
[30] Guo, L., et al., Effects of Traditional Chinese Exercise Yijinjing on Disability and Muscle Strength Among Patients with Chronic Low Back Pain: Protocol for a Randomized Controlled Trial. JMIR Res Protoc, 2025. 14: p. e67557.