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Research Article

Integrative Approaches in Traditional Chinese Medicine: Mechanistic Insights into Neural Repair and Osteoarticular Regeneration

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Abstract

Traditional Chinese Medicine (TCM) integrates multimodal interventions, such as acupuncture, manual therapy, and herbal medicine, to address complex disorders involving neural degeneration, skeletal injury, and musculoskeletal impairment. In clinical practice, Osteoarthritis (OA) is a long-term degenerative joint condition marked by the breakdown of articular cartilage, changes in subchondral bone, and ongoing pain with functional limitations,and peripheral nerve injury is a common medical problem that can be caused by sharp instruments, firearms, stretching or compression. it affects over one million people worldwide annually, making it a global clinical issue with a substantial socioeconomic cost. This study synthesizes evidence from three investigations: (1) Electroacupuncture (EA) at GB30/ST36 alleviates sciatic nerve injury by suppressing autophagy in rats; (2) Meridian-based manual therapy improves shoulder mobility and modulates serum inflammatory cytokines (e.g., IL-10, TGF-β, TNF-α) in frozen shoulder patients; (3) Huangqi Guizhi Wuwu Decoction (HGWD) promotes osteogenic differentiation of bone marrow mesenchymal stem cells (BMSCs) via ESR1 upregulation. These findings highlight autophagy regulation, immunomodulation, and stem cell differentiation as key mechanistic pathways through which TCM modalities exert their reparative effects. Collectively, these findings bridge traditional TCM practices with modern molecular insights, emphasizing autophagy regulation, immune response modulation, and stem cell differentiation as convergent therapeutic pathways. These results advocate for TCM integration into evidence-based regenerative medicine. This integrative approach not only deepens the scientific understanding of TCM mechanisms but also supports its clinical application in managing complex musculoskeletal and neurological conditions, offering promising avenues for developing novel treatment strategies that combine traditional wisdom with contemporary biomedical research.

Keywords

Electroacupuncture, Autophagy, Peripheral Nerve Injury, Frozen Shoulder, Osteogenic Differentiation, HGWD, ESR1

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1. Introduction

Peripheral nerve injuries (PNI) and degenerative joint diseases like osteoarthritis (OA) pose substantial clinical challenges[1-3] due to limited regenerative capacity and incomplete functional recovery. While surgical and pharmacological interventions provide symptomatic relief, they often fail to address underlying pathophysiology [4, 5]. Traditional Chinese Medicine (TCM) offers alternative strategies through multimodal approaches, including acupuncture, manual therapy, and herbal medicine [6-8].

Recent studies highlight the mechanistic basis of TCM: electroacupuncture (EA) modulates autophagy in nerve repair [9]; manual techniques regulate inflammatory cytokines [10]; and herbal formulas like HGWD target osteogenic pathways [11]. This paper synthesizes findings from three studies to elucidate how TCM interventions bridge traditional practices with modern molecular biology, offering novel insights for regenerative medicine.

2. Methods

2.1. Study Design

1) EA experiments: Sciatic nerve crush model in SD rats; EA at GB30/ST36 (15 min/day, 7 days)[9].
2) Clinical trial: 120 frozen shoulder patients randomized to meridian-based manual therapy or conventional massage [10].
3) Cellular assays: BMSC isolation, osteogenic induction, and ESR1 knockdown [11].

2.2. Analytical Approaches

Network pharmacology (TCMSP, STRING), Western blot, qPCR, ELISA, histomorphometry, and functional scales (SFI, VAS). Statistical analysis used ANOVA with Tukey's test ($p<0.05$).

3. Results

3.1. EA Suppresses Autophagy to Accelerate Nerve Regeneration

EA at GB30/ST36 significantly improved sciatic functional index (SFI) and histomorphometric parameters (e.g., myelinated fiber count). Western blot revealed downregulation of autophagy markers (LC3B-II/I, Beclin-1) and upregulation of p62.

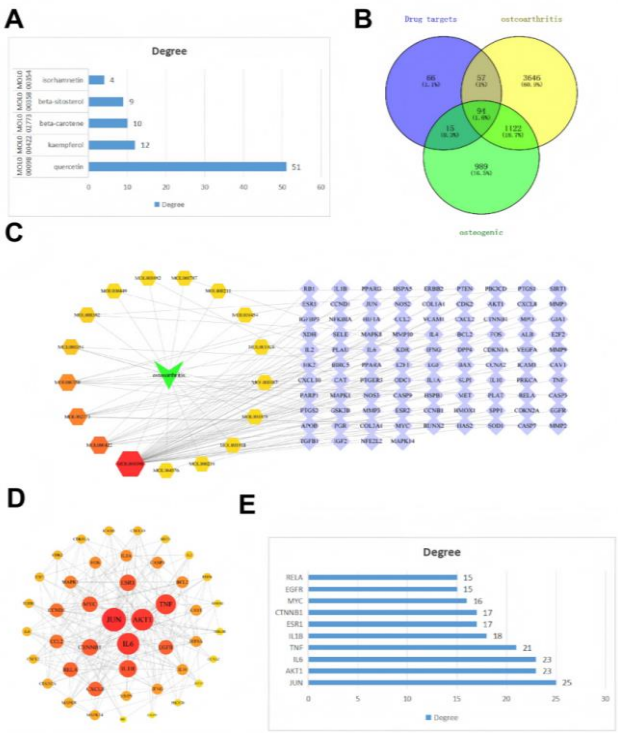

Figure 1. *Network pharmacology analysis of the active components and core target screening of HGWD. A The primary active compounds of HGWD; B Venn diagram showing the overlap between drug targets of HGWD and osteoarthritis related disease targets; C "Herbal component-target-disease" network for HGWD in the treatment of osteoarthritis, con structed using Cytoscape; D protein–protein interaction network of shared targets between HGWD and osteoarthritis; E Core targets of HGWD in the treatment of osteoarthritis.*

3.2. Manual Therapy Modulates Inflammation in Frozen Shoulder

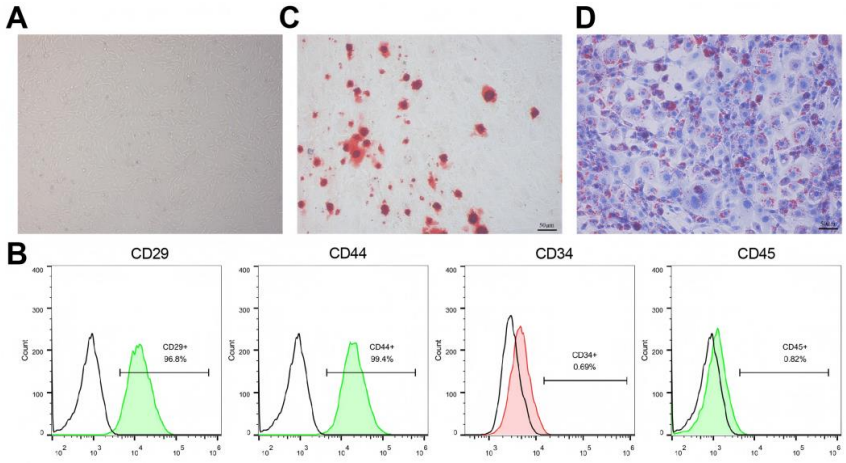

Figure 2. *Identification of rat BMSCs. A morphology of BMSCs observed under a microscope; B surface markers of BMSCs were detected by flow cytometry; C osteogenic differentiation ability of BMSCs was assessed using Alizarin Red staining; D adipogenic differentiation ability of BMSCs was assessed using Oil Red O staining. BMSCs, bone marrow mesenchy mal stem cells*

Meridian-based manual therapy outperformed conventional massage, with higher clinical efficacy (90% vs. 71.67%), reduced VAS scores, and improved shoulder mobility. Serum analysis showed elevated IL-10 and decreased TGF-β/TNF-α.

3.3. HGWD Promotes Osteogenesis via ESR1

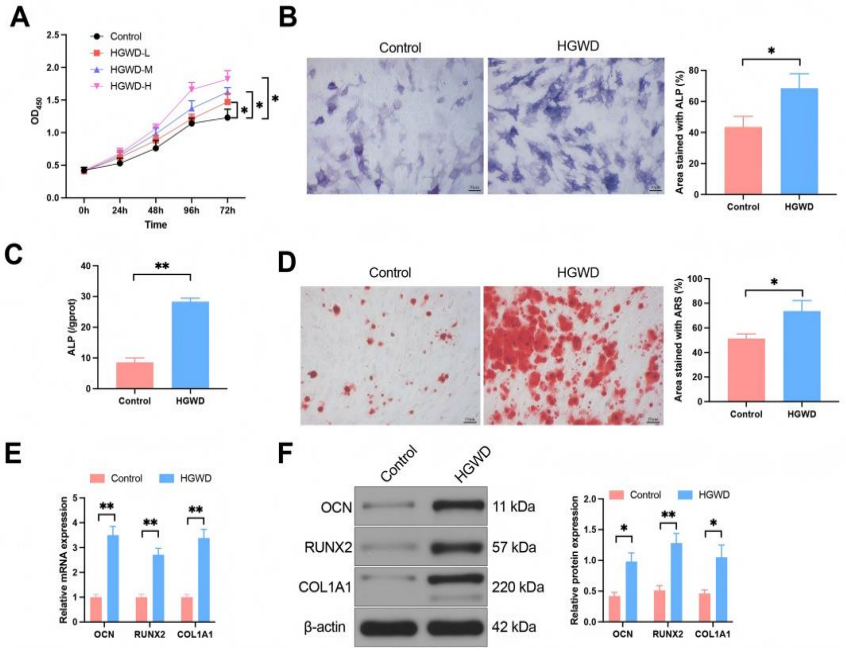

Figure 3. *HGWD promotes osteogenic differentiation of BMSCs. A after BMSCs were treated by HGWD-containing serum, the proliferation ability of BMSCs was detected using CCK-8 assay. BMSCs were treated by 10% HGWD-contain ing serum before induction of osteogenic differentiation. B ALP staining; C detection on ALP activity; D Alizarin Red staining; E–F OCN, RUNX2 and COL1A1 expression level was detected by qRT-PCR and western blot. *, $p < 0.05$; **, $p < 0.01$;***, $p < 0.001$*

HGWD-containing serum enhanced BMSC proliferation and osteogenic differentiation (ALP activity, mineralization). ESR1 knockdown reversed these effects, confirming ESR1 as a critical target.

4. Discussion

4.1. Convergent Mechanisms

EA, manual therapy, and HGWD collectively target dysregulated pathways: autophagy inhibition, immunomodulation, and osteogenic activation. These mechanisms align with established pathways (e.g., mTOR, Nrf2) [12-14], providing a molecular basis for TCM efficacy.

4.2. Clinical Implications

The multimodal TCM approach addresses both symptoms and underlying pathophysiology. For example, EA's autophagy regulation complements HGWD's osteogenic effects, suggesting synergistic potential in combined therapies [15, 16].

4.3. Limitations and Future Directions

Further studies should optimize intervention parameters (e.g., EA frequency, HGWD dosage) and validate findings in larger cohorts. Longitudinal tracking of functional outcomes will strengthen clinical relevance [17, 18].

These findings align with established pathways (e.g., mTOR, Nrf2) [19, 20] and highlight TCM's potential in personalized regenerative strategies.

5. Conclusion

TCM modalities-EA, manual therapy, and HGWD-exert reproducible effects through specific molecular mechanisms. This integration of traditional practices with modern science supports TCM's role in regenerative medicine. This integrative approach not only deepens the scientific understanding of TCM mechanisms but also supports its clinical application in managing complex musculoskeletal and neurological conditions, offering promising avenues for developing novel treatment strategies that combine traditional wisdom with contemporary biomedical research.

Abbreviations

HGWD	Huangqi Guizhi Wuwu Decoction
TCM	Traditional Chinese Medicine
BMSCs	Bone Marrow Mesenchymal Stem Cells
PNI	Peripheral Nerve Injury
OA	Osteoarthritis
EA	Electroacupuncture

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1) Auxiliary Nature: AI is only a tool; research ideas and scientific conclusions entirely originate from the authors.
2) Professional Verification: All AI outputs were double-verified using traditional medicine knowledge and modern scientific methods.

Conflicts of Interest

The authors declare no competing interests.

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