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Analysis of the Impact of Modified Fuyuan Huoxue Decoction on Inflammatory Factors, Immune Function, and Bone Metabolism Indicators in Patients After Surgery for Limb Fractures

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Abstract: *Objective:* This study aims to analyze the specific effects of modified Fuyuan Huoxue Decoction on inflammatory factor levels, immune function status, and bone metabolism-related indicators in patients after surgery for limb fractures. *Methods:* A total of 100 patients who underwent surgery for limb fractures in the orthopedics department of our hospital from January 2025 to January 2026 were selected and randomly divided into an observation group and a control group, with 50 patients in each group. The control group received only conventional Western medical treatment after surgery, while the observation group received additional intervention with modified Fuyuan Huoxue Decoction on the basis of the same treatment as the control group. Both groups were treated continuously for 4 weeks. Changes in serum inflammatory factors, immune function, and bone metabolism indicators were compared between the two groups before and after treatment. *Results:* After treatment, the reduction in serum interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), and C-reactive protein (CRP) levels in the observation group was significantly greater than that in the control group ($P < 0.05$). The percentages of $CD3^+$ and $CD4^+$ T lymphocytes and the $CD4^+/CD8^+$ ratio increased significantly in both groups ($P < 0.05$), with the observation group showing significantly higher values than the control group ($P < 0.05$). Serum bone gla protein (BGP) and procollagen type I N-terminal propeptide (PINP) levels increased significantly in both groups ($P < 0.05$), while β-C-terminal telopeptide of type I collagen (β-CTX) levels decreased significantly ($P < 0.05$), with the observation group showing significantly greater improvement than the control group ($P < 0.05$). *Conclusion:* Modified Fuyuan Huoxue Decoction can effectively reduce postoperative inflammatory responses, improve immune function, regulate bone metabolism balance, and promote fracture healing in patients with limb fractures, making it worthy of clinical promotion.

Keywords: Modified Fuyuan Huoxue Decoction; Limb fractures; Postoperative; Inflammatory factors; Immune function; Bone metabolism

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1. Introduction

Fractures of the extremities represent one of the most prevalent traumatic conditions in clinical orthopedics, often resulting from direct or indirect violence and frequently accompanied by varying degrees of soft tissue injury [1]. Surgical treatment stands as the primary approach for addressing fractures of the extremities, effectively restoring anatomical alignment at the fracture site and limb function. However, the trauma induced by the surgery itself can trigger a robust stress response in the body, leading to the release of a large number of inflammatory factors and the onset of systemic inflammatory response syndrome. This, in turn, suppresses the body's immune function, increasing the risk of postoperative complications such as infection. Furthermore, fracture healing is a complex biological process involving the interaction between osteoblasts and osteoclasts. Postoperative disturbances in bone metabolism directly impact the speed and quality of fracture healing, potentially resulting in delayed union or nonunion. Therefore, effectively mitigating postoperative inflammatory responses, improving immune function, regulating bone metabolism balance, and promoting fracture healing have emerged as hot topics in orthopedic clinical research [2,3]. In recent years, the advantages of traditional Chinese medicine in fracture treatment have become increasingly evident. Fuyuan Huoxue Decoction, originating from *Medical Innovations*, is a classic formula renowned for its effects in promoting blood circulation, removing blood stasis, soothing the liver, and dredging the meridians. It is commonly used to treat traumatic injuries with blood stasis obstruction. Modern pharmacological studies have confirmed its anti-inflammatory, analgesic, microcirculation-improving, and tissue-repair-promoting effects [4,5]. This study aims to analyze the specific impacts of the modified Fuyuan Huoxue Decoction on inflammatory factor levels, immune function status, and bone metabolism-related indicators in patients following surgery for fractures of the extremities.

2. Materials and methods

2.1. General information

A total of 100 patients who underwent surgery for fractures of the extremities in the orthopedics department of our hospital from January 2025 to January 2026 were included and equally divided into an observation group and a control group, with 50 cases in each group. In the observation group, there were 28 males and 22 females, aged 18–65 years, with a mean age of 42.35 ± 10.26 years. Among them, 38 underwent open reduction and internal fixation, and 12 underwent closed reduction and internal fixation. In the control group, there were 26 males and 24 females, aged 19–64 years, with a mean age of 41.87 ± 9.94 years. Among them, 36 underwent open reduction and internal fixation, and 14 underwent closed reduction and internal fixation. The baseline data of the two groups ($P > 0.05$) suggested comparability between the groups.

Inclusion criteria: (1) Confirmed fractures of the extremities by X-ray or CT; (2) Admission and surgery within 72 hours after injury; (3) Aged 18–65 years; (4) No severe heart, liver, or kidney diseases, no immune dysfunction or blood system diseases; (5) No use of drugs affecting immunity or bone metabolism within 3 months before enrollment.

Exclusion criteria: (1) Pathological or old fractures; (2) Concomitant severe soft tissue injury or vascular nerve injury; (3) Concomitant infectious diseases or malignant tumors.

2.2. Treatment methods

The control group received routine postoperative Western medical treatment: routine anti-infection, analgesia,

and decongestion; immobilization and elevation of the affected limb, guiding patients in early functional exercises; supplementation with calcium and vitamin D; and nutritional support therapy.

The observation group received combined treatment with the modified Fuyuan Huoxue Decoction in addition to the control group's treatment. The basic formula consisted of 15g *Bupleurum*, 12g *Trichosanthes* root, 12g *Angelica sinensis*, 9g *Carthamus tinctorius*, 6g Licorice, 6g *Hirudo* (processed with hot water), 30g *Rhei Radix et Rhizoma* (processed with wine), and 15g *Persicae Semen*. Modifications: For severe pain, add 6g *Olibanum* and 6g *Myrrha*; for significant swelling, add 12g *Lycopus lucidus* and 15g *Leonuri Herba*; for qi and blood deficiency, add 30g *Astragali Radix* and 15g *Codonopsis pilosula*; for liver and kidney deficiency, add 15g *Eucommiae Cortex* and 15g *Dipsaci Radix*. One dose per day, decocted in water to obtain 400ml of juice, taken warmly in the morning and evening, for 4 consecutive weeks of treatment.

2.3. Observation indicators

Fasting venous blood samples (5ml) were collected before treatment and after 4 weeks of treatment, and serum was separated by centrifugation. Inflammatory factors: IL-6 and TNF-α were detected by ELISA, and CRP was detected by immune turbidimetry. Immune function: $CD3^+$ and $CD4^+$ T lymphocyte percentages were detected by flow cytometry, and the $CD4^+/CD8^+$ ratio was calculated. Bone metabolism indicators: BGP, PINP, and β-CTX were detected by chemiluminescence.

2.4. Statistical methods

Data were processed using SPSS 26.0 software. Continuous variables are presented as mean ± standard deviation (SD) and compared using *t*-tests; categorical variables are presented as percentages (%) and compared using chi-square tests. A *P*-value less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of inflammatory factor levels before and after treatment between the two groups of patients

After treatment, the levels of the aforementioned indicators in the observation group were significantly lower than those in the control group ($P < 0.05$). See **Table 1** for details.

Table 1. Comparison of inflammatory factor levels (mean ± SD)

Group	*n*	IL-6 (pg/ml)		TNF-α (pg/ml)		CRP (mg/L)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation group	50	35.62 ± 8.74	12.35 ± 3.26	28.45 ± 6.32	9.67 ± 2.14	45.26 ± 10.35	8.42 ± 2.15
Control group	50	34.89 ± 8.51	18.72 ± 4.15	27.98 ± 6.15	15.23 ± 3.08	44.78 ± 10.12	14.69 ± 3.27
t	-	0.423	8.535	0.377	10.483	0.234	11.329
P	-	0.673	0.000	0.707	0.000	0.815	0.000

3.2. Comparison of immune function indicators before and after treatment between the two groups of patients

After treatment, the aforementioned indicators in the observation group were significantly higher than those in the control group ($P < 0.05$). See **Table 2** for details.

Table 2. Comparison of immune function indicators (mean ± SD)

Group	*n*	$CD3^+$ (%)		$CD4^+$ (%)		$CD4^+/CD8^+$	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation group	50	58.32 ± 6.45	68.75 ± 5.26	32.15 ± 4.26	40.67 ± 3.84	1.23 ± 0.21	1.68 ± 0.25
Control group	50	57.89 ± 6.23	63.42 ± 5.18	31.78 ± 4.12	35.89 ± 3.76	1.21 ± 0.20	1.42 ± 0.22
t	-	0.339	5.076	0.390	6.289	0.488	5.521
P	-	0.735	<0.001	0.697	<0.001	0.627	<0.001

3.3. Comparison of bone metabolism indicators between the two groups before and after treatment

After treatment, the improvement in the aforementioned indicators in the observation group was significantly better than that in the control group ($P < 0.05$). See **Table 3** for details.

Table 3. Comparison of bone metabolism indicators (mean ± SD)

Group	*n*	BGP (ng/ml)		PINP (ng/ml)		β-CTX (ng/ml)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation group	50	8.76 ± 2.15	16.32 ± 3.24	32.45 ± 6.78	68.72 ± 10.35	0.87 ± 0.21	0.42 ± 0.12
Control group	50	8.59 ± 2.08	12.45 ± 2.87	31.89 ± 6.54	52.36 ± 9.42	0.85 ± 0.20	0.63 ± 0.15
t	-	0.402	6.322	0.420	8.266	0.488	7.730
P	-	0.689	<0.001	0.670	<0.001	0.627	<0.001

4. Discussion

After surgery for extremity fractures, the body experiences a series of pathophysiological changes due to surgical trauma. Firstly, surgical trauma activates the body's inflammatory response system, leading to the activation of inflammatory cells such as monocytes/macrophages and neutrophils. These cells release inflammatory factors such as IL-6, TNF-α, and CRP, which play a role in clearing necrotic tissue and promoting tissue repair. However, excessive release of inflammatory factors can also lead to systemic inflammatory response syndrome, exacerbate tissue damage, and affect fracture healing [6]. Secondly, surgical trauma triggers a stress response in the body, leading to the excitation of the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system. This results in the massive secretion of hormones such as glucocorticoids and catecholamines, which inhibit the proliferation and differentiation of T lymphocytes, thereby reducing the body's immune function. This increases the risk of postoperative complications such as infections. Moreover, fracture healing is a complex process involving multiple cells and cytokines, and the balance between osteoblasts and osteoclasts is crucial for normal fracture healing. Postoperative factors such as inflammation, stress response, and immobilization can reduce osteoblast activity and increase osteoclast

activity, disrupting bone metabolism balance and leading to greater bone resorption than bone formation, thereby affecting the speed and quality of fracture healing [7,8].

Traditional Chinese medicine posits that the basic pathogenesis of fractures is "external injury to the limbs leads to internal damage to qi and blood, disrupting the circulation of nutrient and defensive qi and causing disharmony among the internal organs." After traumatic injury, blood stasis blocks the meridians, impeding the circulation of qi and blood and causing pain. Treatment should focus on promoting blood circulation to remove blood stasis and soothing the liver to unblock the meridians [9]. Fuyuan Huoxue Decoction, originating from Li Dongyuan's *Medical Innovations*, is a classic formula for treating traumatic injuries and blood stasis obstruction [10]. Rhubarb processed with wine is used as the principal drug in a relatively heavy dosage, primarily to eliminate condensed stagnant blood resulting from traumatic injuries and guide the pathogenic factors of blood stasis downward, thereby achieving the effect of eliminating the old and fostering the new. *Angelica sinensis*, peach kernel, and safflower promote blood circulation to remove blood stasis, reduce swelling, and alleviate pain. Leech processed by branding breaks up blood stasis to unblock the meridians and reduces swelling and dissipates masses. Licorice relieves spasms and alleviates pain while harmonizing the actions of the other ingredients and serves as the envoy drug. When combined, these drugs work together to promote blood circulation to remove blood stasis and soothe the liver to unblock the meridians, thereby eliminating blood stasis, generating new blood, unblocking the meridians, and stopping pain.

After treatment, the serum levels of IL-6, TNF-α, and CRP in the observation group were significantly lower than those in the control group, which was related to the anti-inflammatory effects of various drug components in Fuyuan Huoxue Decoction. These components can inhibit the activation of inflammatory signaling pathways such as NF-κB, reduce the release of inflammatory factors, and alleviate tissue damage caused by inflammatory responses.

The percentages of $CD3^+$ and $CD4^+$ T lymphocytes and the $CD4^+/CD8^+$ ratio in the observation group were significantly higher than those in the control group ($P < 0.05$). The stress response caused by surgical trauma can lead to a decrease in immune function. However, drug components such as *Bupleurum* and *Angelica sinensis* in Fuyuan Huoxue Decoction have immunomodulatory effects, promoting the proliferation and differentiation of T lymphocytes, enhancing cellular immune function, and reducing the incidence of postoperative complications such as infections.

After treatment, the serum levels of BGP and PINP in the observation group were significantly higher than those in the control group, while the level of β-CTX was significantly lower ($P < 0.05$). This indicates that modified Fuyuan Huoxue Decoction can effectively regulate bone metabolism balance in patients after extremity fracture surgery. BGP is a non-collagenous protein synthesized and secreted by osteoblasts and serves as a specific indicator of osteoblast activity. PINP is a product of type I collagen synthesis and is an important indicator of bone formation. β-CTX is a product of type I collagen degradation and is a specific indicator of bone resorption. Fuyuan Huoxue Decoction can promote the proliferation and differentiation of osteoblasts, enhance osteoblast activity, and promote bone formation while inhibiting osteoclast activity and reducing bone resorption, thereby regulating bone metabolism balance and promoting fracture healing [11].

5. Conclusion

In summary, the use of modified Fuyuan Huoxue Decoction to treat patients after extremity fracture surgery

can achieve the following effects: reducing the level of inflammatory response in the body, enhancing immune function, and promoting fracture healing. This approach holds significant clinical application value. The results of this study provide a scientific basis for the application of traditional Chinese medicine in the postoperative management of extremity fractures. However, due to the small sample size and short observation period of this study, the long-term efficacy and safety still require further large-sample, multicenter, randomized controlled trials to confirm.

Disclosure statement

The author declares no conflict of interest.

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