ORIGINAL RESEARCH

Effect of Exercise Rehabilitation Combined with Alfacalcidol Administration on Patellofemoral Traumatic Dysfunction

Zhaoyu Chen, BM; Zijian Ma, BM; Jiaxiang Gao, BM; Yan Gao, BM; Fengyao Mei, BM

ABSTRACT

Objective • To investigate the efficacy and clinical value of alfacalcidol combined with exercise rehabilitation in therapy of the postoperative dysfunction of patients with patella fractures.

Methods • In this study, 100 patients who underwent patella fracture surgery at Peking University People's Hospital between April 2018 and December 2019 were randomly selected and divided into a control group (n=50) and an experimental group (n=50) by lottery. The control group received exercise therapy, while the experimental group received alfacalcidol based on exercise rehabilitation. The functional assessment measure (FAM) score, visual analog scale (VAS) score, therapy efficiency, adverse effects, callus volume, and callus density were compared between the two groups.

Results • The FAM score and therapy efficiency in the experimental group were significantly higher than in the control group [$P < .001$, *RR: 95%*CI (10.28, 5.12 to 15.52)], but the VAS score was lower [$P < .001$ RR: 95% CI (22.83, 1.99 to 3.31)]. Patients in the experimental group had fewer adverse effects [$P < .001$, RR: 95% CI (14.62, 6.49 to 32.92)] than those in the control group but significantly larger callus volume and density [both $P < .001$, RR: 95% CI (26.03, 3.21 to 4.07): (17.92, 2.83 to 3.34)].

Conclusion • Alfacalcidol combined with exercise rehabilitation therapy could significantly improve motor function, callus volume, and callus density in patients with patella fracture, resulting in a high applicable value in managing postoperative functional impairment of patellar fractures. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Patella fractures are a significant medical concern that can significantly affect the normal movement and function of the knee joint. The patella, being the largest sesamoid bone in the human knee joint, plays a crucial role in supporting the knees during extension. When a patella fracture occurs, it can significantly interfere with the normal movement of the knee joint, causing functional impairment and discomfort for patients.[1-3] Patellar fractures, classified as a subset of fractures in traditional Chinese medicine, are relatively less prevalent in clinical practice compared to other types of fractures. Research indicates that the incidence of patellar fractures ranges from 1.2 to 6.1 cases per 100 000 individuals per year, with transverse fractures being the most common type. Elderly patients, particularly those experiencing low-energy mechanisms commonly associated with fragility fractures, are more susceptible to patellar fractures, with reported incidence rates of 13.1 cases per 100 000 elderly individuals per year.[2] Given the increasing trend of population aging, it is anticipated that the incidence of patellar fractures will rise. Osteoporosis-related fractures and complications are becoming increasingly common, particularly in the aging population. The etiology of osteoporosis after fracture surgery is complex and varied, leading to long-term pain, slow healing, and varying degrees of disability. According to Chinese medicine, surgery greatly injures the body's vital energy, and insufficient kidney energy can contribute to the development of osteoporosis. In Chinese medicine, osteoporosis is associated with kidney deficiency, spleen deficiency, liver stagnation, blood stasis, and insufficient nourishment of tendons and bones. Therefore, the treatment of osteoporosis should focus on benefiting Qi and strengthening the spleen, nourishing Yin and tonifying the kidneys, regulating Qi and blood circulation, and enhancing drug and calcium absorption.[4]

Orthopedic surgeries, especially those involving lower limb fractures, often lead to complications such as deep vein thrombosis (DVT) in the lower limbs due to prolonged bed rest, strict immobilization, and altered hemodynamics. Consequently, patients undergoing patellar fracture surgery are at risk of developing DVT. Additionally, patients' motor function may be affected to varying degrees following patellar fracture surgery, resulting in functional impairment and restricted mobility.[5]

Patella fractures are commonly caused by strenuous exercise, impacts, and jumping without proper cushioning. If left untreated or not properly managed, these fractures can lead to complications such as patellofemoral pain syndrome, also known as "runner's knee" or "anterior knee pain." This condition is characterized by diffuse, non-traumatic pain in the front, sides, or back of the patella. The pain is often triggered or aggravated by activities like squatting, walking up and down stairs, running, and jumping. With the increasing popularity of national fitness programs in recent years, there has been a rise in the incidence of patellofemoral pain syndrome due to a lack of professional guidance and inadequate control of exercise patterns and intensity. Effective management of patella fractures involves a combination of postoperative medication and rehabilitation.[4-6] Postoperative medication typically includes drugs that promote blood circulation remove blood stasis, prevent infection, and address osteoporosis in older patients. One commonly used drug for osteoporosis is alfacalcidol, an analog of oestriol. Alfacalcidol enhances bone mass and muscle strength by promoting intestinal absorption of calcium and phosphorus. However, long-term administration of alfacalcidol may lead to adverse effects and drug resistance. To mitigate these risks, traditional Chinese medicine (TCM) often combines alfacalcidol with Chinese herbal medicine to improve calcium absorption and reduce adverse effects.[7,8]

Rehabilitation plays a crucial role in the recovery of patients with patella fractures. Early rehabilitation exercises aim to prevent joint stiffness and pressure sores and improve daily living activities. Proper rehabilitation therapy can significantly contribute to the healing process and functional recovery of patients with patella fractures.[8] Therefore, it is important to explore the effectiveness of rehabilitation interventions in improving postoperative dysfunction and promoting the overall recovery of patients with patella fractures.

The objective of this study is to investigate the efficacy and clinical value of combining alfacalcidol with exercise rehabilitation in the therapy of postoperative dysfunction in patients with patella fractures. This is done by comparing the improvement in dysfunction between patients who receive alfacalcidol and exercise rehabilitation and those who receive exercise rehabilitation alone. The study hypothesizes that the combination of alfacalcidol and exercise rehabilitation will lead to greater improvement in motor function, callus volume, and callus density compared to exercise rehabilitation alone in patients with patella fractures.

MATERIALS AND METHODS

General Materials

In this research, 100 patients who underwent patella fracture surgery in our hospital from April 2018 to December 2019 were randomly selected and separated by lottery into a control group (n=50) and an experimental group (n=50).

Randomization was carried out using an online web-based randomization tool (freely available at http://www.randomizer.org/). For concealment of allocation, the randomization procedure and assignment were managed by independent research assistants who were not involved in the screening or evaluation of the participants.

The original sample size calculation estimated that 50 patients in each group would be needed to detect a 3-point difference between groups in a 2-sided significance test with a power of 0.8 and an alpha error level of .05

The trial was conducted in accordance with the standards of *Good Clinical Practice* and the *Declaration of Helsinki*.[9] The trial protocol and all amendments were approved by the appropriate ethics body at each participating institution. All patients provided written informed consent prior to enrolment. The trial protocol has been published online and is available with the full text of this article.

Inclusion and Exclusion Criteria

Inclusion Criteria. (1) Patients with the clinical manifestations of postoperative dysfunction after patella fracture surgery. (2) Patients whose ages were ≥18 years old. (3) Patients without any drug allergy, drug abuse history, and any bad habits. (4) Patients with normal coagulation function who recently did not have taken anticoagulant drugs. (5) Peking University People's Hospital's ethics committee has approved this study, and all patients participated in it voluntarily and signed an informed consent letter.

Exclusion Criteria. (1) Patients who had recently received other surgical therapies. (2) Patients who had a mental disorder and could not cooperate with researchers in this study. (3) Patients who had fractures in other parts.

Methods

Patients in both groups were all treated with postoperative stent fixation therapy and the same nursing care.

In the control group, patients underwent exercise rehabilitation following surgery, guided by medical staff instructions. Postoperative exercises focused on the lower limbs and included circuit training with fixed movements. Patients were positioned supine, with both legs raised and slowly lowered at a rate of 20 times per minute, for a duration of 5 minutes, repeated 6 times per day.

In the experimental group, in addition to exercise rehabilitation, patients received alfacalcidol (manufacturer: China Resources Double-Crane Pharmaceutical Co., Ltd.; National Medicine NO.H20074109; specification: 0.25μg). Alfacalcidol was administered orally as 1 capsule per dose, twice daily, for a duration of 30 days per course.

Both groups received treatment with Jianpi Yishen Ziyin Tang, a Chinese herbal formula composed of the following ingredients: Huangshi (Radix Astragali) 20g, Baishao (Radix Paeoniae Alba) 20g, Yinyanghuo (Herba Epimedii) 15g, Buguzhi (Fructus Psoraleae) 15g, Roucongrong (Herba Cistanches) 15g, Danshen (Radix Salviae Miltiorrhizae) 15g, Duzhong (Cortex Eucommiae) 15g, Dazao (Fructus Jujubae) 15g, Yujin (Radix Curcumae) 15g, Nuzhenzi (Fructus Ligustri Lucidi) 15g, Chuanjizi (Semen Cuscutae) 10g, Gancao (Radix Glycyrrhizae) 5g. The herbal decoction was prepared once daily by boiling the ingredients in water, resulting in a 300mL decoction, which was divided into two doses (morning and evening). The treatment duration for both groups was 1 month.

Observation Indexes

The functional assessment measure (FAM) scores, pain scores of visual analog scale(VAS) therapeutic efficacy, adverse reactions, callus volume, and density, were compared between the two groups.

The FAM motor function score, ranging from 0 to 100, is used to evaluate the severity of dyskinesia, with higher scores indicating lower severity. A score of 96-100 indicates mild dyskinesia, 85-95 indicates severe dyskinesia, 50-84 indicates significant dyskinesia, and scores below 50 indicate extremely severe dyskinesia.

The Visual Analog Scale (VAS) pain scale assessed postoperative pain levels in both groups. A score of zero represents no pain, while scores of 1-3 indicate mild and bearable pain. Scores of 4-6 signify pain that interferes with sleep quality but remains tolerable, while scores of 7-10 reflect severe and unbearable pain. A score of 2-3 indicates good analgesia, while scores of 3 or higher indicate incomplete analgesia.

The effectiveness of the treatment was determined by evaluating various factors. Significantly effective outcomes were characterized by the absence of significant swelling, deformity, congestion, or other abnormalities at the fracture site, along with a notable reduction in healing time. Effective outcomes indicated improved swelling and reduced healing time. Ineffective outcomes were associated with significant swelling, congestion, and no reduction or even an increase in healing time.

Callus volume and callus density scores were used to assess fracture healing through imaging tests. A score of zero indicated clear fracture ends with no callus growth. A score of 1 indicated blurred fracture ends with low callus density and some callus growth. A score of 2 represented increased callus density and a gradual darkening of the callus color. A score of 3 indicated callus color essentially matching that of normal bone.[10-12]

Statistical Processing

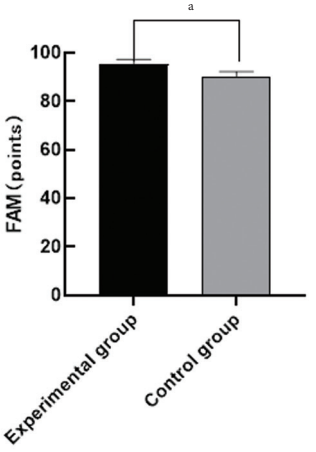
The mean difference between the two groups was tested using a *t* test for normally distributed variables and a Mann-Whitney U test for non-normal variables.

All data in this study were dealt with by software SPSS20.0 and imaged using GraphPad Prism 7 (GraphPad Software, San Diego, USA). This study involved count data and measurement data. The measurement data were described as ($\bar{x} \pm s$) applying the *t* test. The count data were described as n(%) using the χ^2 test. $P < .05$ indicates that the difference was statistically significant.

Table 1. Comparison of general materials ($\bar{x} \pm s$)

group		Experimental group	Control group	χ^2/t	*P* value
Gender(male/ female)		33/17	35/15	0.18	.67
Age(years old)		28.34±2.29	28.61±2.44	0.57	.57
Height(cm)		172.09±10.69	172.58±10.11	0.24	.81
Weight(kg)		75.55±6.40	75.28±6.32	0.21	.83
Hospitalization time(h)		1.52±0.62	1.57±0.58	0.42	.68
History of smoking(years)		3.00±1.07	3.08±1.21	0.35	.73
History of drinking(years)		4.62±1.13	4.53±1.05	0.41	.68
Causes of injury	Falling from a high place	7	8	0.08	.78
	Traffic accidents	18	15	0.41	.52
	Tumble	13	15	0.20	.66
	Crash	12	12	<0.001	1.00

Figure 1. Comparison of FAM movement scores



[a]indicates that the comparison of FAM movement score among the experimental group and the control group (95.34±2.06) vs (90.22±2.03), t=12.52, $P < .001$.

Note: The X-axis represents the experimental group and the control group from left to right, and the Y-axis means the FAM movement score.

RESULTS

General Data

Patients in the experimental group were 20-33 years old, and patients in the control group were 19-35. No significant difference was discovered in general materials, such as gender, age, weight, etc., among the two selected groups, and the results were not statistically obvious ($P > .05$). Table 1.

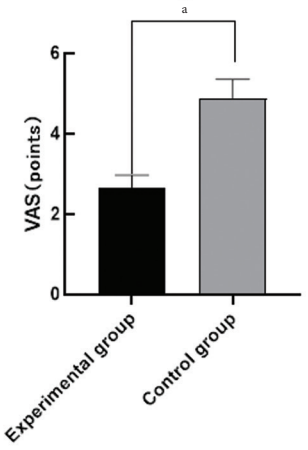
Comparison of FAM Score

Comparing the motor function of patients in the two groups and evaluating their progress, the results showed that patients in the experimental group had higher FAM scores than those in the control group. ($P < .05$). Figure 1.

Comparison of VAS Pain Scores

Comparing the VAS pain scores of the two enrollment groups, the results revealed that the experimental group had lower VAS pain levels than those in the control group. ($P < .05$). Figure 2.

Figure 2. Comparison of VAS pain score



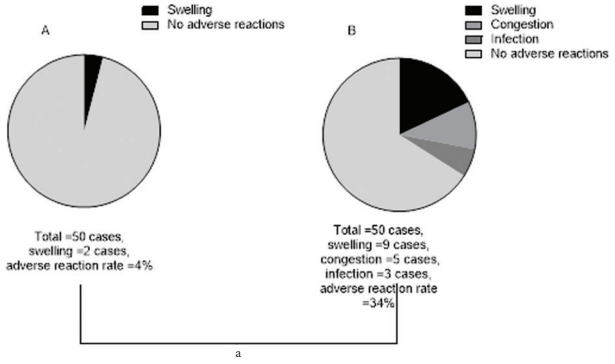
[a]indicates that the comparison of the VAS pain score of the two groups (2.64±0.33) vs (4.88±0.48), t=27.19, P < .001.

Note: The X-axis represents the experimental group and the control group from left to right, and the Y-axis means the VAS pain score.

Table 2. Comparison of the effective rate of therapy

group	Marked effective	Effective	Ineffective	Total effective rate (%)
Experimental group	27	19	4	92%
Control group	14	21	15	70%
χ^2				7.86
P value				.005

Figure 3. Comparison of the incidence of adverse



[a]shows the comparison of the occurrence of adverse reactions among the experimental group and the control group (χ^2=14.62, P < .001).

Note: Figure A indicates the occurrence of adverse reactions in the experimental group. There were 2 patients with swelling at the fracture and 48 patients without adverse reactions, and the adverse reactions occurrence was 4%. Figure B indicates the occurrence of adverse reactions in the control group. There were 9 patients with swelling at the fracture, 5 patients with congestion, and 3 patients with infection, and the occurrence of adverse reactions was 34%.

Table 3. Comparison of callus volume and callus density scores ($\bar{x} \pm s$)

group	Callus volume	Callus density
Experimental group	3.64±0.22	3.30±0.30
Control group	2.57±0.19	2.26±0.28
t	26.03	17.92
P value	<.001	<.001

Comparison of the Effective Rate of Therapy

Comparing the effective rates of the two groups, the results showed that the effective rate of the experimental group was obviously higher (92% vs 70%, P < .05). Table 2.

Comparison of Adverse Reaction Rates

Comparing the adverse reactions of the two groups during rehabilitation, the results showed that patients in this study suffered from adverse reactions primarily including swelling, congestion, and infection at the fracture, and patients in the experimental group had a lower incidence of adverse reactions than those in the control group. (P < .05). Figure 3.

Comparison of Callus Volume and Callus Density Scores

Evaluating the callus volume and callus density scores of the two selected groups based on the imaging test findings, the results revealed that patients in the experimental group had higher callus volume and callus density than those in the control group. (P < .05). Table 3.

DISCUSSION

Patellar fracture is a common type of traumatic bone injury often caused by direct trauma or indirect muscle tension. This fracture is frequently associated with symptoms such as pain, joint dysfunction, and restricted mobility, posing significant challenges to patients' quality of life and recovery. Addressing patellar fractures requires a multifaceted approach to treatment and rehabilitation.

Our study investigates the efficacy of a combined intervention involving alfacalcidol supplementation, exercise rehabilitation, and potentially traditional Chinese herbal medicine in the management of postoperative dysfunction in patients with patellar fractures. This intervention aims to enhance bone healing and remodeling, improve joint function, and alleviate pain, thereby facilitating the recovery process for patients with this debilitating injury. By exploring the synergistic effects of these interventions and their individualized application, we seek to optimize treatment outcomes and contribute to the advancement of care for individuals suffering from patellar fractures.

The combination of alfacalcidol and exercise rehabilitation in the therapy of postoperative dysfunction in patients with patella fractures has shown promising efficacy and clinical value, as demonstrated in this study. The improved outcomes observed in the experimental group can be attributed to several underlying mechanisms and factors, as well as the inclusion of traditional Chinese herbal medicine in the treatment approach.

Enhanced Bone Healing and Remodeling: Alfacalcidol, an analog of osteotriol, plays a significant role in promoting bone recovery. It enhances the absorption of calcium and phosphorus in the intestines, thereby improving bone mass and muscle strength. This mechanism likely contributed to the increased callus volume and callus density observed in the experimental group. Alfacalcidol's ability to promote blood circulation and remove blood stasis may have facilitated the healing process in patients with patella fractures.[13,14]

Synergistic Effects of Alfacalcidol and Exercise Rehabilitation: Exercise rehabilitation is crucial for improving joint function, preventing stiffness, and enhancing overall motor function. When combined with alfacalcidol, the therapeutic outcomes may have been synergistically enhanced. Alfacalcidol's effects on bone healing, coupled with the targeted exercises provided by rehabilitation, likely resulted in improved motor function and reduced pain levels in the experimental group.[15-18] Feng *et al.* (2020) proposed that alfacalcidol could significantly improve the therapeutic outcome of patients with traumatic tibiofibular fractures, ameliorate clinical manifestations such as swelling and ecchymosis, etc., and obviously shorten the healing time moreover, enhance scores in volume and bone callus density,[19] which is consistent with the findings of this study and adequately demonstrates the scientific reliability of this study.

Individualized Treatment and Patient Compliance: The combined intervention approach allowed for individualized treatment based on each patient's specific needs and condition. By incorporating exercise rehabilitation, the treatment could be tailored to address the unique challenges and limitations faced by patients with patella fractures. This individualized approach may have improved patient compliance and engagement, leading to better therapeutic outcomes.

Traditional Chinese Herbal Medicine: The document mentions that Chinese herbal medicine is usually used in combination with alfacalcidol in clinical practice. While the specific herbal medicines are not mentioned in the document, it can be inferred that the inclusion of Chinese herbal medicine in the treatment approach may have contributed to the positive outcomes observed. Traditional Chinese herbal medicine often focuses on promoting overall health and balance in the body, which may have synergistic effects with alfacalcidol and exercise rehabilitation in improving the outcomes of patients with patella fractures. Further research is needed to explore the specific herbal medicines used and their mechanisms of action in this context.

Jianpi Yishen Ziyin Tang, a Chinese herbal formula, was used in the study to invigorate the spleen, strengthen muscles and bones, soothe the liver, relieve heat, nourish blood and Yin, activate blood circulation, and remove blood stasis. The experimental group that received alfacalcidol and rehabilitation therapy showed higher overall efficiency compared to the control group, indicating that Jianpi Yishen Ziyin Tang effectively relieved clinical symptoms.[8]

The results of the study demonstrated that the experimental group had higher FAM motor function scores compared to the control group, indicating that alfacalcidol combined with exercise rehabilitation significantly improved motor function and promoted recovery. The treatment efficiency of the experimental group was also higher, suggesting that alfacalcidol combined with exercise rehabilitation therapy increased treatment efficiency, improved prognosis, and shortened recovery time. Alfacalcidol, which can be converted to the active form of vitamin D, calcitriol, bypassing activation in the kidney, may contribute to these positive outcomes. The herbs in Jianpi Yishen Ziyin Tang nourish the liver and kidneys, strengthen muscles and bones, and promote osteoblast proliferation.[20,21]

Additionally, Jianpi Yishen Ziyin Tang improved mobility and reduced pain significantly. Pain associated with patella fractures can lead to fear of movement and further loss of bone mass. The herbs in the formula invigorate blood, improve Qi and blood circulation, and have pain-relieving effects. Furthermore, imaging tests revealed that the callus volume and callus density scores were higher in the experimental group compared to the control group, indicating improved fracture healing. The incidence of adverse reactions was also lower in the experimental group.

However, this study still has a number of shortcomings due to a number of constraints: (1) in terms of the study sample, the sample size collected in this trial was relatively small, and it was not possible to evaluate the significant differences in postoperative efficacy between the two groups from the perspective of a large sample size; (2) in terms of observation indicators and efficacy determination, this study used more subjective efficacy assessment criteria, and there were large differences in subjective feelings between individuals, different cultural levels, and differences in understanding of the questions in the scale. (2) this study used more subjective efficacy assessment criteria for observational indicators and efficacy determination. It was difficult to give an absolutely objective and accurate description of the assessment on the scale because of the differences in subjective feelings between individuals, their different levels of education, and their understanding of the questions on the scale.

CONCLUSION

In conclusion, the combination of alfacalcidol and exercise rehabilitation, along with the potential inclusion of traditional Chinese herbal medicine, shows promise in improving motor function, callus volume, and callus density in patients with patella fractures. The underlying mechanisms include enhanced bone healing and remodeling, synergistic effects of the combined intervention, and individualized treatment approaches. Further investigations are warranted to optimize the treatment protocol, explore the specific herbal medicines used, and evaluate the long-term effects of this combined intervention in a broader patient population.

CONFLICT OF INTEREST

All authors declared that they have no financial conflict of interest.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article.

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