



Original Article

## The effect of external fixator on bone metabolism in patients with open fracture of extremities



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### Abstract

This experiment aimed to explore the influence mechanism of external fixator on open fracture. A total of 128 patients with open tibiofibular fractures were included in this study. The patients were randomly divided into external fixator group (n=64) and control group (n=64) according to the order of admission. Double-blind controlled observation was used. The levels of osteocalcin (BGP),  $\beta$ -CTX, P1 NP, BALP, including haptoglobin (Hp), ceruloplasmin (CER), serum adrenocorticotropic hormone (ACTH), cortisol (COR), C-reactive protein (CRP), white blood cell (WBC) and interleukin-6 (IL-6) were recorded in different groups. The postoperative VAS score and quality of life were recorded. Log-rank was used to analyze the difference in postoperative adverse reaction rates among different groups. External fixation stent treatment increased BGP, PINP, and BALP expression and decreased  $\beta$ -CTX, Hp, CER, ACTH, COR, CRP, WBC, and IL-6 levels. Patients in the external fixation stent group had significantly lower VAS score quality of life scores and incidence of adverse events than the control group. External fixation stents protect open fracture patients by promoting bone metabolism.

**Keywords:** Open fracture of extremity, External fixation brace, Bone metabolism, Osteocalcin, Quality of life.

### 1. Introduction

Recently, with the development of transportation and construction industry in China, open tibiofibular fracture has become one of the most common fracture types in clinical orthopedics[1, 2]. Clinical studies have shown that the tibia and fibula have shallow subcutaneous, skin and soft tissue coverage is less, no rich muscle tissue protection, so it is easy to form open fractures[3]. Open tibiofibular fracture is an open injury, which has the characteristics of a high wound contamination rate and long hospitalization time. Moreover, patients are prone to adverse conditions such as wound infection, delayed healing or long-term treatment, which seriously affects the quality of life of patients[4, 5].

Traumatic fractures of the extremities are common in clinical practice, which seriously reduce the quality of life of patients[6]. At this stage, they are mainly treated by internal fixation surgery and have satisfactory therapeutic effects[7]. However, clinical experience shows that internal fixation surgery mainly connects broken bones directly through related materials such as metal screws and steel plates, which has certain curative effect. However, postoperative patients often have the occurrence of infection, which in turn causes secondary injury, which also limits

the application of internal fixation surgery in traumatic fractures of limbs[5, 8]. The development of fixed support technology, it has the advantages of simple operation, small trauma, short fracture healing time, broad clinical application prospect, better-fixed effect of affected limb and faster recovery of limb function. The external fixator can be used to fix the fracture site by using an external fixator made of aluminum alloy, stainless steel and titanium alloy. It can help the rapid reduction of the fracture and increase the stress stimulation in the fracture section[9]. In addition, most parts of the combined external fixator can be recombined after interchange, which has a reciprocal effect on the shear force of the section and has good versatility and dexterity, so as to facilitate, quickly and effectively carry out the surgical fixation of limb traumatic fracture, and lay a solid foundation for the early functional recovery training of patients. The results of this study suggest that the combined external fixator has a good application effect in the surgical treatment of limb fractures, which helps shorten the operation time and accelerate postoperative recovery. CRP is an acute-phase protein synthesized by hepatocytes, and inflammatory stimuli such as tissue injury or microbial invasion can accelerate the rapid increase in its level and enhance its inflammatory response [10]. PINP

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belongs to the bone tissue-specific collagen[11], and BGP is specifically secreted by osteoblasts[12]. Studies have confirmed that its level has a positive correlation with the function or activity of osteoblasts.

Therefore, this study intends to explore the effect of external fixator on patients with open fractures of limbs from the perspective of bone metabolism, in order to reveal its specific mechanism of action.

## 2. Materials and Methods

### 2.1. Study Subjects

A total of 128 patients with open tibiofibular fractures who were treated in our hospital from December 2018 to February 2023 were randomly divided into control group (Control, n = 64) and external fixator group (EF, n = 64) according to the order of admission. The inclusion criteria of all subjects are as follows: (1) Age  $\geq$  18 years old, diagnosed as open tibiofibular fracture by imaging combined with clinical symptoms, and no previous history of tibiofibular fracture; (2) It is suitable for the treatment of steel plate internal fixation; (3) No cognitive impairment, able to communicate normally. Exclusion criteria are as follows: (1) patients with severe heart, liver and kidney dysfunction; (2) Hematopoietic and coagulation system disorders; (3) Combined with severe nerve or vascular injury; (4) Combined with malignant tumor; (5) those with a history of mental illness and vague thinking consciousness; (6) Poor compliance, unable to accept regular follow-up. This study was approved by the ethics committee of our hospital. In accordance with the Declaration of Helsinki, informed consent was obtained from all patients or their relatives.

After admission, the two groups of patients underwent thorough debridement, removal of inactivated tissues and foreign bodies, and maximum protection and repair of tissue blood vessels, nerves and tendons. The control group underwent plate internal fixation. The patients were in supine position and underwent epidural anesthesia. The appropriate plate was selected according to the injury. After the debridement, the fracture site was reset, and the plate was embedded in the anterior side of the tibia and fibula and fixed with screws. The observation group was treated with unilateral multifunctional external fixator. The injury of the fracture was observed, and the appropriate unilateral multifunctional external fixator was selected. After the debridement, the fracture was reset. If the fracture was spiral or oblique, it was necessary to select the appropriate entry point, percutaneous drilling, screw fixation and adjustment of the external fixator.

Blood samples were collected from the elbow vein in the morning of 7 days after operation. The serum bone metabolism indexes, including osteocalcin (BGP), type I collagen carboxyl terminal  $\beta$  special sequence ( $\beta$ -CTX), type I procollagen amino terminal extension peptide (PINP) and bone alkaline phosphatase (BALP), were measured by electrochemiluminescence immunoassay.

Elisa kits were used to detect the level of acute phase reactive protein in serum of patients, including haptoglobin (Hp), C-reactive protein (CRP), and ceruloplasmin (CER).

### 2.2. Observation indicators

The levels of serum adrenocorticotrophic hormone (ACTH), cortisol (COR), C-reactive protein (CRP),

white blood cell (WBC) and inter-leukin-6 (IL-6) in the two groups were measured. The kit was purchased from Shanghai Joe Feather Biotechnology Co., Ltd. (Shanghai, China).

### 2.3. Pain level score

Visual analogue scale (VAS): The VAS scores of the 2 groups of patients before receiving care and 1 month after receiving care were recorded[13]. Among them, a score of 0 is no pain; 1~3 is mild incisional pain, which is tolerable; 4~6 is significant pain, which interferes with sleep; 7~10 represents unbearable pain and requires other analgesic methods.

### 2.4. Quality of life assessment

Patient quality of life (QoL) was measured using the Medical Outcomes Study 36-item Short Form (SF-36) test[14-16]. Scores are based on the SF-36 Manual and Explanatory Guide [17].

### 2.5. Poor prognosis

All patients were followed up for 6 months after discharge from the hospital. During the follow-up, patients with the following were considered to have an adverse prognosis: infection, nerve damage, hematoma formation, or re-hospitalization.

### 2.6. Statistical analysis

SPSS 24.0 (IBM Corp.) and GraphPad Prism 6.01 (GraphPad Software Inc.) were used for statistical analysis and graph construction, respectively. For continuous variables with normal distribution, the data is described as mean  $\pm$  standard deviation (SD). For non-normally distributed variables, the data are described as median and quartile range (IQR); for categorical variables, the data is described as quantity. Kolmogorov-Smirnov test was used to evaluate the normality of the distribution in continuous variables. When the variables are normally distributed, the independent sample t-test is used, otherwise the Mann-Whitney U test is used. The survival curve was drawn according to Log-Rank analysis to analyze the predictive value of external fixator for adverse reactions in patients with Open tibiofibular fractures. P was a two-sided test, and  $P < 0.05$  was considered statistically significant.

## 3. Results

### 3.1. Clinical baseline characteristics

A total of 128 study subjects were included in this study. According to Table 1, it can be seen that there was no statistical difference in age, sex, and cause of fracture between the control group (Control) and the external fixator group (EF) (all  $P > 0.05$ ), while BGP,  $\beta$ -CTX, PINP, BALP, Hp, CRP, and CER were statistically different ( $P < 0.05$ ).

### 3.2. External fixation brace reduces stress factor levels in patients with fractures

To investigate the effect of external fixation stents on patients' stress levels, we examined the serum stress factor levels in both groups. The results showed that the postoperative serum ACTH, COR, CRP, WBC, and IL-6 levels were significantly decreased in the stent group compared with the control group (Table 2, all  $P < 0.001$ ).

**Table 1.** Comparison of clinical characteristics.

		Control(n=64)	EF(n=64)	t/C <sup>2</sup>	P
Age		45.21±6.11	46.54 ± 6.75	1.169	-
Gender	Male	47	42	0.923	-
	Female	17	22		
Cause of fracture	Traffic accidents	21	25	2.059	-
	Falling	7	10		
	Crush injuries others	14 22	9 20		
BGP (ng/mL)		15.24±5.27	22.13±6.78	6.419	< 0.001
β-CTX (pg/mL)		231.15±2.38	148.48±2.69	184.1	< 0.001
PINP (ng/mL)		39.38±2.33	43.15±2.38	9.055	< 0.001
BALP (U/L)		152.92±0.51	180.62±0.24	393.2	< 0.001
Hp		18.42±2.78	10.91 ± 1.44	19.19	< 0.001
CER		21.34±3.36	14.26±2.19	14.12	< 0.001

Notes: BGP, Bone Gla-protein; β-CTX, Human type I collagen terminal peptide β Degradation products; PINP, Propeptide of type I procollagen; BALP, Bone Alkaline Phosphatase; Hp, Haptoglobin; CER, Ceruloplasmin.

**Table 2.** Stress factor levels in patients.

	Control (n=64)	EF (n=64)	t	P
ACTH (mg/L)	22.15±3.24	19.29±2.48	5.608	<0.001
COR (ng/mL)	559.13±35.82	452.31±31.15	18.00	<0.001
CRP (mg/L)	10.82±1.62	6.39±1.23	17.42	<0.001
WBC (×10 <sup>9</sup> /L)	10.44±0.85	8.02±0.74	17.18	<0.001
IL-6 (ng/mL)	31.66±2.13	23.84±1.63	23.32	<0.001

**Table 3.** Effect of external stent fixation on patients' pain and quality of life.

	Control(n=64)	EF(n=64)	P
VAS score	23 (21,25)	19 (17,20)	<0.001
Total SF-36 score	63 (58,71)	79 (74,84)	<0.001

### 3.3. Effect of external fixation stents on patients' pain and quality of life

To investigate the effect of external fixation stents on patients' lives, pain scores and quality of life were assessed. VAS scores were significantly higher in the control group than in the stent group, while Total SF-36 scores were significantly lower in the control group than in the stent group (Table 3, all  $P < 0.001$ ).

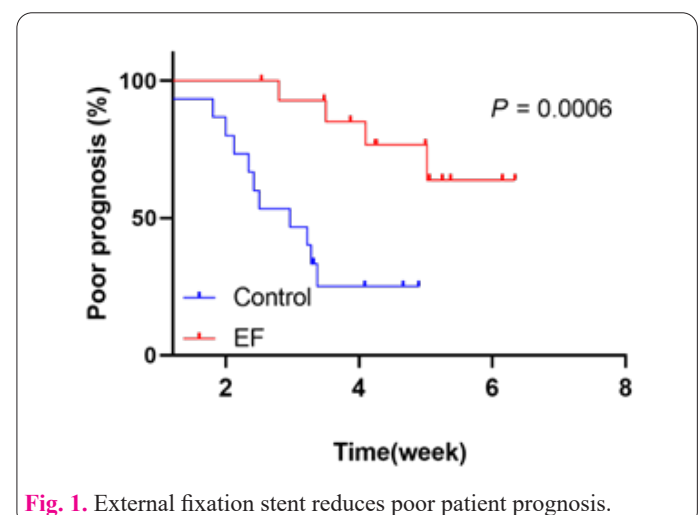
### 3.4. External fixation reduced poor patient prognosis

To assess whether there is a certain association between external brace fixation and the incidence of postoperative adverse reactions in fracture patients, we took a Log-rank survival analysis. The results as shown in Figure 1 showed that the incidence of adverse reactions was significantly lower in the external stent fixation group than in the conventional control group (Log Rank  $P = 0.0006$ ). This implies that external stent fixation reduces the adverse prognosis of patients.

## 4. Discussion

The incidence of open tibiofibular fracture is a common clinical fracture of long tubular bones, and its incidence has increased significantly in recent years due to the development of transportation industry and industrial technology innovation. Open tibiofibular fractures are mostly caused by direct violence, such as punching and striking[18]. Because the tibia and fibula are two bones at the same level

and different planes, the fracture line is often at different planes[19]. If not treated in time, it will lead to wound infection, poor prognosis or inability to heal. Therefore, the prognosis recovery of patients with open tibiofibular fractures has always been a problem that clinical medical staff pay close attention to. At present, the clinical treatment of the disease is mostly treated with plate internal fixation or unilateral multifunctional external fixator. Although plate internal fixation can achieve certain curative effects, it often causes certain damage to the surrounding soft tissue and periosteum during the operation, thus affecting the

**Fig. 1.** External fixation stent reduces poor patient prognosis.

prognosis of patients. In addition, this treatment may lead to plate exposure or bone exposure, which is easy to cause infection[20]. In view of the above factors, some areas initially tried to use unilateral multifunctional external fixator for treatment. The operation time is short, the operation is simple, the wound is small, and the postoperative adjustment is convenient. After operation, the external fixator can be adjusted to close the fracture site to avoid the occurrence of malunion and other adverse conditions. At the same time, the multifunctional external fixator has a certain strength, hardness and stability, which can produce pressure on the fracture end, promote the growth of callus, accelerate fracture healing and improve the quality of fracture healing[21]. The results of this study showed that the total effective rate of treatment in the observation group was significantly higher than that in the control group ( $P < 0.05$ ), which confirmed that the unilateral multifunctional external fixator was more effective in the treatment of open tibiofibular fractures. The interaction between osteoclasts and osteoblasts is the basic process of fracture healing. BGP, PINP, BALP and  $\beta$ -CTX are all factors closely related to osteoblasts[21]. BGP is one of the typical bone formation markers, which can enter the bone matrix and bind to osteoblasts through vitamin K-dependent calcium-binding protein[22]. PINP represents osteoblast activity and can reflect the rate of type I collagen synthesis[23]. BALP directly reflects the functional status and activity of bone cells and is one of the surface markers of osteoblasts[24].  $\beta$ -CTX represents the function and activity of osteoclasts. When the activity of osteoclasts is enhanced, the degradation of  $\beta$ -CTX increases and is released into blood[25-27]. In this study, the BGP, PINP, and BALP levels in the study group were significantly higher than those in the control group, while the  $\beta$ -CTX levels were significantly lower than those in the control group ( $P < 0.05$ ), suggesting that unilateral multifunctional external fixation brace treatment can more effectively promote fracture end healing and improve the quality of fracture healing. The expression levels of Hp, CRP and CER were positively correlated with the degree of trauma and infection, i.e., the serum levels of Hp, CRP and CER increased significantly during trauma and infection. In this study, the postoperative Hp, CRP, and CER levels in the study group were significantly lower than those in the control group ( $P < 0.05$ ), suggesting that unilateral multifunctional external fixation brace treatment can reduce trauma and infection in patients and more effectively optimize the body condition and restore the anatomical position of the fracture end. In addition, the overall complication rate of the study group was significantly lower than that of the control group ( $P < 0.05$ ), indicating that unilateral multifunctional external fixation brace treatment has a higher safety. In conclusion, the unilateral multifunctional external fixation brace was effective in the treatment of open tibiofibular fractures, with the advantages of improving trauma and infection, and the fracture end healed well, which is safe and reliable and worthy of clinical promotion.

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### Conflict of interests

The author has no conflicts with any step of the article

preparation.

### Consent for publications

The author read and approved the final manuscript for publication.

### Availability of data and material

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### Authors' contributions

SY conducted the experiments and wrote the paper; NF, LZ, TY, JJ, XP, MN, GB and LB analyzed and organized the data; GF conceived, designed the study and revised the manuscript.

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