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Original Article

Surgical effects and prognosis of non-rigid internal fixation for ankle fractures combined with tibiofibular syndesmotic injuries

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Abstract: Objective: The aim of this study was to investigate the effects of non-rigid internal fixation in the treatment of ankle fractures combined with tibiofibular syndesmotic injuries. Methods: Ninety patients with ankle fractures and tibiofibular syndesmotic injuries, treated in the Department of Orthopedics in the 4th (Xing Yuan) Hospital of Yulin, from January 2014 to December 2017, were included in this study. Included patients were randomized into an observation group and control group, with 45 cases in each group. Patients in the observation group underwent non-rigid internal fixation while the control group of patients received traditional screw fixation. Operation time, operation angle, time to achieve complete weight-bearing ambulation, incidence of surgical complications, American Orthopedic Foot Ankle Society (AOFAS) scores, and excellent rates in the two groups were compared at 6 months postoperative follow up. Results: No significant differences were noted in operation time between the two groups ($P>0.05$). The observation group showed a higher operation angle, shorter time to achieve complete weight-bearing ambulation, and lower incidence of surgical complications than the control group, with statistically significant differences ($P<0.05$). At 6 months postoperative follow up, AOFAS scores and excellent rates in the observation group were obviously higher than those in the control group, with statistically significant differences ($P<0.05$). Conclusion: For patients with ankle fractures, combined with tibiofibular syndesmotic injuries, non-rigid internal fixation is worthy of clinical application due to the easy operation, early complete weight-bearing ambulation, low incidence of complications, and good recovery of ankle joint function.

Keywords: Ankle fracture, tibiofibular syndesmotic injuries, non-rigid internal fixation, surgical effects

Introduction

The ankle joint, also known as the talocrural joint, is composed of the lower articular surface of the tibia and fibula and the trochlear of talus. It is one of the most important joints in the human body [1, 2]. Studies have shown a high prevalence of injuries to ankle joints due to the special anatomical structure and function of supporting basic exercises such as standing, walking, and running [3, 4]. Among ankle joint injuries, closed ankle fractures, combined with tibiofibular syndesmotic injuries, often fail to heal, greatly increasing the difficulty of clinical treatment and aggravating patient pain. Delayed or improper treatment may lead to aggravation of ankle joint stability and even induce traumatic osteoarthritis, seriously affecting the quality of life of affected patients [5, 6].

Internal fixation is the preferred treatment of ankle fracture, with screw fixation as the predominant option. Anatomical reduction and internal fixation of distal tibiofibular fractures can effectively promote the recovery of ankle joint function [7, 8]. However, some studies have reported that, as a means of rigid fixation, screw fixation is prone to screw loosening and rupturing affected by micro-kinetic biomechanics at the tibiofibular junction of ankle joints. Some patients have endured a secondary operation due to remove screws [9]. Recent studies have demonstrated that non-rigid internal fixation has good biomechanical advantages in the

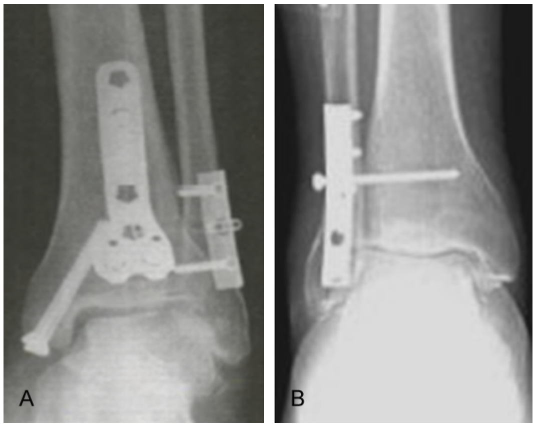

Figure 1. Internal fixation of ankle joint fracture combined with tibiofibular syndesmotic injuries. A: Non-rigid fixation; B: Traditional screw fixation.

treatment of joint fractures, achieving the stability of a rigid internal fixation [10]. At present, few reports are available regarding application of non-rigid internal fixation for treatment of ankle fractures combined with tibiofibular syndesmotic injuries. Therefore, this study was designed to investigate the effects of non-rigid internal fixation with an aim of guiding clinical treatment.

Materials and methods

Subjects

All patients enrolled in this study provided informed consent. The study was approved by the Hospital Ethics Committee. Ninety patients with ankle fractures and tibiofibular syndesmotic injuries, treated in the Department of Orthopedics in the 4th (Xing Yuan) Hospital of Yulin, from January 2014 to December 2017, were included in this study. Enrolled patients were randomized into an observation group and control group, with 45 cases in each group. Patients in the observation group underwent non-rigid internal fixation while the control group of patients underwent conventional screw fixation. Inclusion criteria included: (1) Patients with definite diagnosis as closed ankle fractures, combined with tibiofibular syndesmotic injuries, according to clinical manifestations and medical imaging examination; (2) Patients with surgical indications or without surgical contraindications; (3) Patients with fracture onset up to 1 week prior; and (4) Patients that actively cooperated with this study. Exclusion criteria included: (1) Patients with open fractures and other concurrent traumas; (2) Patients with pathological fractures; (3) Patients with concurrent osteoporosis; (4) Patients with severe cardio-cerebrovascular disease and underlying diseases such as liver and kidney dysfunction; (5) Patients with mental disease; and (6) Pregnant and lactating women.

Surgical methods

All patients received fixations under epidural anesthesia. Different positions were selected according to different sites of ankle fractures. Patients with medial malleolus fractures and tibiofibular syndesmotic injuries were placed in the supine position, while those with lateral and posterior malleolus fractures were placed in the lateral position. After the fractures were treated with reduction fixation, patients in the observation group received non-rigid coracoclavicular ligament reconstruction using Tightrope. First, the joint was drilled from the fibular bone to the tibial bone 3 cm proximal to the articular surface. The drill was kept parallel to the articular surface during the process. Subsequently, an incision was made in the medial skin and the reconstructed steel plate was placed into the bone via the guide wire, then sutured and fixed through a tie. Finally, the Hook experiment (Bone hook was applied to the lateral malleolus and given 100 N stress. As shown by anteroposterior and lateral X-ray films during surgery, lateral malleolus shifted over 2 mm outward.) was performed to ensure reduction of the ankle joints and normal function of the lower tibiofibula. In the control group, a 3.5 mm screw was placed posteriorly from the fibular bone to the tibial bone 3 cm above the articular surface. Reduction of the ankle joints and function of the lower tibiofibula were checked normally using a C-arm X-ray machine. After surgery, all patients were given second-generation cephalosporin for anti-inflammation, detumescence, and other symptoms (**Figure 1**).

Outcome measures

The following indicators were compared between the two study groups: operation time, operation angle of fixation for distal tibiofibular joint, time to achieve complete weight-bearing ambulation, and incidence of postoperative complications (including internal fixation loosening, rupture, internal fixation-caused skin irritation, and abruption of lower tibiofibular liga-

Table 1. Comparison of baseline information between the two groups of patients

	Observation group	Control group	t/χ^2	P
Case	45	45		
Male/Female (n)	28/17	30/15	0.194	0.660
Age (year)	36.4±2.4	37.1±2.6	0.343	0.749
Fracture laterality (Left/Right, n)	27/18	30/15	0.431	0.512
Cause of injury (n)			1.421	0.491
Traffic accident	16	13		
Falling	10	15		
Bruise	19	17		
Fracture classification (n)			0.259	0.879
Pronation-external rotation	20	21		
Pronation-abduction	14	15		
Supination-external rotation	11	9		

Table 2. Comparison of operation time and operating angle between the two groups of patients

	Case	Operation time (min)	Operation angle (°)
Observation group	45	12.2±1.3	47.3±4.6
Control group	45	10.6±0.9	26.9±3.3
t		1.753	6.241
P		0.155	0.003

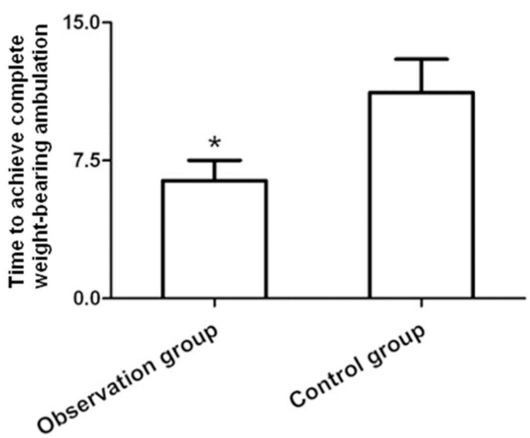

Figure 2. Comparison of time to achieve complete weight-bearing ambulation between the two groups of patients. *P<0.05, compared with the control group.

ment union). American Orthopedic Foot Ankle Society (AOFAS) scores at 6 months postoperatively were recorded: total score was 100 points, with higher score indicating better clinical efficacy; scores for excellent: 90-100 points, scores for good: 75-89 points; and scores for average: less than 75 points. Excellent rate was calculated as ratio of patients with excellent and good efficacy, that is (number of patients with excellent efficacy + number of patients with good efficacy)/total number of patients * 100%.

Statistical analysis

Statistical analysis of all data was performed using SPSS 20.0 software. Measurement data are expressed as mean ± standard deviation and comparison between groups was conducted using independent-sample t-tests. Enumeration data are represented as a percentage and Chi-square test was used for comparison between groups. $P<0.05$ was considered a statistically significant difference.

Results

Comparison of baseline information between the two groups of patients

There were no significant differences in gender, age, fracture laterality, cause of injury, and fracture classification between the two groups, as shown in **Table 1**.

Comparison of operation time and operation angle between the two groups of patients

No significant differences in operation time were found between the two groups of patients. Operation angle of the observation group was significantly greater than that in the control group and differences between the two groups were statistically significant (P=0.003), as shown in **Table 2**.

Comparison of time to achieve complete weight-bearing ambulation between the two groups of patients

Compared with the control group (11.2±1.8 weeks), time to achieve complete weight-bearing ambulation was significantly shortened in the observation group (6.4±1.1 weeks), with significant differences observed (t=3.941, P=0.017), as shown in **Figure 2**.

Table 3. Comparison of complication incidence between the two groups of patients (n, %)

	Case	IFL	IFR	IFCSI	ALTLU	OC
Control group	45	3 (6.7)	2 (4.4)	2 (4.4)	3 (6.7)	10 (22.2)
Observation group	45	0 (0.0)	0 (0.0)	1 (2.2)	1 (2.2)	2 (4.4)
χ^2						6.644
P						0.027

Note: IFL denotes internal fixation loosening; IFR, internal fixation rupture; IFCSI, internal fixation-caused skin irritation; ALTLU, abruption of lower tibiofibular ligament union; OC, overall complications.

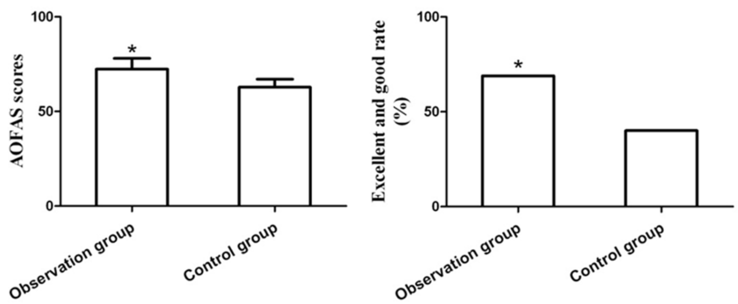

Figure 3. Comparison of AOFAS scores and excellent rates between the two groups of patients. *P<0.05, compared with control group.

Comparison of complications between the two groups of patients

In the control group, 3 cases showed internal fixation loosening, 2 cases showed internal fixation ruptures, 2 cases showed internal fixation-caused skin irritation, and 3 cases showed abruption of lower tibiofibular ligament union. Overall complication incidence was 22.2%. In the observation group, internal fixation-caused skin irritation was found in 1 case and abruption of lower tibiofibular ligament union was found in 1 case, but there was no internal fixation loosening or rupturing. Overall complication incidence was 4.4%. Differences in overall complication incidence between the two groups were statistically significant (P=0.027), as shown in **Table 3**.

Comparison of AOFAS scores and excellent rates between the two groups of patients

After patients were followed up at 6 months post-surgery, AOFAS score in the observation group was 72.4±5.6 points while the excellent rate was 68.9% (31/45). The AOFAS score of patients in the control group was 62.8±4.2 points and the excellent rate was 40.0% (18/45). AOFAS scores (P=3.756, P=0.004) and excellent rates (χ^2=7.571, P=0.006) showed significant differences between the two groups, as shown in **Figure 3**.

Discussion

The lower tibiofibula is composed of the tibiofibular ligament, transverse ligament, anterior ligament, and posterior ligament. It functions to disperse gravity and resist pulling. It is an important structure for maintaining stability of the ankle joint. Ankle joint fracture is the common disease among ankle joint injuries, often leading to tibiofibular syndesmotic injuries. Improper treatment may induce ankle joint instability and further lead to mismatched tibiotalar joints, cartilage wear, and traumatic sacroiliitis [12, 13]. Currently, the predominant treatment of ankle fractures, combined with tibiofibular syndesmotic injuries, includes screw internal fixation and non-rigid fixation. This present study was designed to compare the effects of non-rigid internal fixation and conventional internal fixation in the treatment of ankle fractures combined with tibiofibular syndesmotic injuries.

In this study, AOFAS scores and excellent rates of patients in the observation group were significantly higher than those in the control group, at 6 months follow up. Differences were significant between two groups. This may be explained by the fact that rigid fixation limits fibular rotation and displacement relative to the tibia and restricts early ankle function training, while non-rigid fixation induces no secondary trauma and allows normal micromotion and dorsal extension of ankle joint, complying with the biomechanical environment and achieving physiological healing [14]. This finding is consistent with results reported by Degroot et al. [15]. Beumer et al. demonstrated that ankle joints with normal motor function require anteroposterior, distal, and external rotation of the distal radius to a certain level [16]. In addition, this study showed no statistically significant differences in preoperative age, gender, cause of injury, and fracture classification between the two groups. No statistically significant differences were found regarding operation time between the two groups. This insignificant difference is possibly caused by intraoperative technique and proficiency. However, the operation angle of patients was significantly increased in the observation group, indicating that non-rigid fixation is characterized by easy operation, low requirement of precision, and automatic reduction within a large range. One previous study has revealed that the average time to achieve complete weight-bearing ambulation was 4.93 weeks in patients undergoing non-rigid fixation and 10.52 weeks in patients undergoing conventional screw fixation [17]. In this present study, patients in the observation group had significantly shorter times to achieve complete weight-bearing ambulation than those in the control group. This could be because non-rigid internal fixation not only achieves similar effects as rigid fixation, but also promotes early ankle functional exercise, increases the contact area of ankle joints, produces uniform force, and significantly improves the biomechanical properties of the feet. In addition, patients in the observation group showed significantly lower incidence of complications than the control group, with significant differences, consistent with a previous report by Sun et al. [18]. Once weight-bearing exercise is absent for a long period after fixation, the joint will become stiff, affecting joint function. Early functional exercise may cause screw loosening and rupturing in rigid internal fixation. Therefore, more than half of patients need surgery to remove the rigid internal fixation device early, due to the possibility of screw rupture and restriction of the range of motion [19, 20]. Another study reported that non-rigid internal fixation for treatment of tibiofibular syndesmotic injuries is a strong fixation, even if placed in a non-anatomical position before fixation, the lower tibiofibular joint will automatically reset to the anatomical position after tightening of the fixation device [21].

In summary, regarding ankle fractures combined with tibiofibular syndesmotic injuries, non-rigid fixation has the advantages of low requirement of operation precision, few postoperative complications, early complete weight-bearing ambulation, and excellent short-term efficacy. However, this study had some limitations. The sample size was quite small and it was a single-center study, with a relatively short follow up period. Future multicenter and large-sample clinical trials with long-term follow ups are needed to confirm the findings of this study.

Disclosure of conflict of interest

None.

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