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Original Article

Effect of early partial weight-bearing rehabilitative exercise on postoperative functional recovery of sanders IV calcaneal fractures

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Abstract: Objectives: This research explored and analyzed the effects of early partial weight-bearing rehabilitative exercise on postoperative recovery after Sanders IV calcaneal fractures. Methods: 86 patients hospitalized with Sanders IV calcaneal fracture from April 2018 to January 2020 were selected as the research participants. The patients were randomly divided into the observation group (n=44) and the control group (n=42). The control group carried out the conventional rehabilitative exercise, and the observation group underwent early partial weight-bearing rehabilitative exercise. The foot function between the two groups was compared after 24 weeks of treatment. Results: The foot function of the observation group after 24 weeks of treatment was notably superior to that of the control group (*P<0.05*). The Maryland foot function scores of the two groups 6 weeks, 12 weeks and 24 weeks post-operation were critically higher than those before treatment (*P<0.05*), and the score of the observation group was substantially higher than that of the control group (*P<0.05*). The AOFAS score of patients in the two groups 6 weeks, 12 weeks and 24 weeks post-operation increased apparently than that before treatment *(P<0.05*), and the scores of observation group was evidently higher than that of control group (*P<0.05*). In addition, the comparison of Angle B'hler and Angle Gissane between the two groups of patients 24 weeks postoperation showed statistically insignificant difference (*P>0.05*). Conclusion: The early partial weight-bearing rehabilitative exercise can effectively promote the postoperative functional recovery of patients with Sander IV calcaneal fractures, and at the same time it has no impact on internal fixation and calcaneus shape of patients, which is worthy popularizing in clinic.

Keywords: Early partial weight-bearing rehabilitative exercise, sanders IV calcaneal fractures, postoperative, functional recovery

Introduction

There are a total of seven tarsal bones in human body. Among which, calcaneus is the largest tarsal bone, and bears about 40% of the body weight when walking and loading [1]. Calcaneal fractures are particularly common in clinical work, and it accounts for 60% of tarsal fractures and 2% of total body fractures. The anatomical structure of calcaneus is special and complex, and the mechanism of calcaneal injury and fracture types are numerous. In addition, as the foot function is connected with a variety of factors such as the shape, anatomical angle and the relative position, it is difficult to achieve anatomical reduction, and usually results in unsatisfactory therapeutic effects [2, 3]. Studies have shown [4] that about 75% of patients have experienced foot dysfunction, and for those with severely injured the disability rate is as high as 30%. Many patients had good surgical reduction, but failed for the recovery of foot function due to the lack of effective postoperative functional exercise. Besides, there still exist controversies about postoperative weight-bearing functional exercise [5]. In order to further improve the postoperative recovery of foot function after Sanders IV calcaneal fracture, we explored and analyzed the effects of early partial weight-bearing rehabilitative exercise exerted to the disease. The details are stated as follows:

Materials and methods

Research objects

86 patients, hospitalized with Sanders IV calcaneal fracture from April 2018 to January 2020, were selected as the research participants. They were randomly divided into the observation group (n=44) and the control group (n=42) according to random number table. The study was approved by the ethics committee of our hospital.

Inclusive criteria

(1) The diagnostic criteria of patients were in accordance with Sanders IV calcaneal fracture in *Bone and Joint Injury*, and the type was fresh simple fracture [6]; (2) All patients had undergone open reduction and internal fixation (ORIF) with steel plate; (3) Patients aged between 18-60 years; (4) Patients had voluntarily signed informed consent.

Exclusive criteria

(1) Patients with Sanders I, II, III calcaneal fractures; (2) Patients with injuries of vital nerves, blood vessels or ligaments; (3) Patients with immune system diseases, endocrine system diseases, etc.; (4) Patients with dysfunctions of heart, brain, liver or kidney; or (5) Patients with mental disorders.

Methods

The control group carried out the regular rehabilitation exercises, and the specific process were as follows: (1) The main treatment from the first day to the second week after surgery was to reduce swelling. The patient raised the injured foot and began to perform passive toe movements 24 hours after operation. The exercise was required to perform in maximum range, 3-5 times/group and 6 groups a day. (2) In the 3rd to 6th week after the operation, the patients continued the above exercises and conducted gentle active and passive exercises of ankle and subtalar joints. The patients were asked to extend their back or plantar flexion as long as they can tolerate, and maintained for 20 seconds. The exercise was set by 3 to 5 times/group, and 6 groups per day. (3) The patients continued to expand the range of motion in ankle joint during 2-7 weeks postoperation. They underwent joint mobilization of subtalar joint, calcaneocubic joint, and talar navicular joint, and passively moved the subtalar joint to gradually restore the range of motion for the three joints. Meanwhile, we adopted the unarmed resistant technique to perform isometric exercises on patients' posterior tibial muscle, tibial anterior muscle, and tibial long brevis muscle in order to strengthen the patients' muscles strength around their ankle joints. (4) According to fracture degree, the patients performed the partial weight-bearing standing or walking in the 13th to 24th weeks after surgery, and gradually increased the exercise intensity to full weight-bearing. The proprioceptive training of patients was carried out by shaking board, so that the patients' proprioceptive system of ankle and foot can be recovered; For gait training, it started by shifting the center of gravity left/right and front/back between the legs; For walking practice, the patients were required to reach the equal support of both feet and same extent in swing phase, until the normal walking gait can be restored.

The observation group conducted the partial weight-bearing rehabilitative exercise, and the specific training program was as follows: The rehabilitative trainings for joint activity, muscle strength and proprioception were the same as those conducted by the control group. While starting from the 4th week postoperatively, these patients received partial weight-bearing training as well. The patients held the parallel rod with both hands, and put the mass measuring instrument under feet to experience the loading weight they can tolerate. The patient's initial loading weight was 25% of his body mass, which ranged from 10 to 20 kg, and then increased progressively. The patients looked straight and walked with crutches in a three-point manner, and started to stand or walk with full weight 13 weeks after surgery.

Observation of indexes

The Maryland foot function scores, including pain and function, were compared between the two groups before surgery, and 6 weeks, 12 weeks, and 24 weeks after surgery [7]. The scale has a full score of 100 points, and the higher score referred to the better foot function. For the earned score, 90-100 is consid-

Table 1. Comparison of clinical data between the two groups of patients

Group	Number of cases	Gender		Age (years old, $\bar{x} \pm sd$)	BMI (kg/m^2, $\bar{x} \pm sd$)	Injured part	
		Male	Female			Left	Right
Observation group	44	25	19	39.18±7.30	23.27±3.10	21	23
Control group	42	22	20	38.75±8.33	23.49±2.71	19	23
t/χ^2	-	0.171		0.255	0.350	0.054	
P	-	0.680		0.799	0.727	0.817	

Table 2. Comparison of foot function between the two groups at 24 weeks after operation [n (%)]

Group	Number of cases	Excellent	Good	Acceptable	Poor
Observation group	44	26 (59.9)	9 (20.45)	5 (11.36)	4 (9.09)
Control group	42	13 (20.95)	12 (28.57)	8 (19.05)	9 (21.43)
Z	-	-2.653			
P	-	0.008			

ered as excellent foot function, 75-89 as good, 50-74 as fair, and <50 as poor foot function.

The AOFAS scores of the two groups before surgery, and 6 weeks, 12 weeks and 24 weeks after surgery were compared [8]. The AOFAS score includes the dimensions of daily activity function, pain and imaging that comprehensively evaluate the patient's ankle function recovery, and the full score is 100 points. The higher AOFAS score of patients reflects the better ankle functions.

The differences of Angle B'hler and Gissane between the two groups 24 weeks postoperation were compared.

Statistical analysis

The analysis of data was processed by SPSS 22.0. The comparison of measurement data was done by *t*-test, enumeration data by χ^2 test, and ordinal data by Kruskal-Wallis test. The statistically significant difference was set by *P<0.05*. The graphic software adopted was Graphpad prism.

Results

Clinical data

There was insignificant difference in clinical data between the two groups (*P>0.05*), as shown in **Table 1**.

Comparison of foot function between two groups of patients 24 weeks after treatment

In observation group, there were 26 cases with excellent foot function (59.9%), 9 cases with good foot function (20.45%), 5 cases with fair foot function (11.36%), and 4 cases with poor performance (9.09%). The proportion of patients in control group were 13 (20.95%), 12 (28.57%), 8 (19.05%) and 9 (21.43%). The foot function of the observation group 24 weeks after treatment was notably superior to that of the control group (*P<0.05*), as shown in **Table 2**.

Comparison of Maryland foot function score between the two groups before and after treatment

There was no significant difference in scores of Maryland foot function before treatment between the two groups (*P>0.05*). The scores of the two groups 6 weeks, 12 weeks and 24 weeks postoperation were critically higher than those before treatment (*P<0.05*), and the observation group had substantially higher scores than the control group (*P<0.05*) (**Table 3** and **Figure 1A**).

Comparison of AOFAS scores between the two groups before and after treatment

There was no significant difference in AOFAS scores before treatment between the two groups (*P>0.05*). The score of both groups of patients 6 weeks, 12 weeks and 24 weeks postoperation increased apparently than those before treatment *(P<0.05*), and the observation group had evidently higher score than the

Table 3. Comparison of Maryland foot function score between the two groups before and after treatment (points, $\bar{x} \pm sd$)

Group	Number of cases	Before treatment	6 weeks postoperatively	12 weeks postoperatively	24 weeks postoperatively
Observation group	44	14.28±3.11	41.26±5.49*	61.73±8.11*	89.74±10.23*
Control group	42	13.97±2.98	36.58±4.85*	53.03±7.52*	81.29±9.52*
t	-	0.472	4.182	5.152	3.961
P	-	0.638	<0.001	<0.001	<0.001

Note: **P<0.05* compared with the same group before treatment.

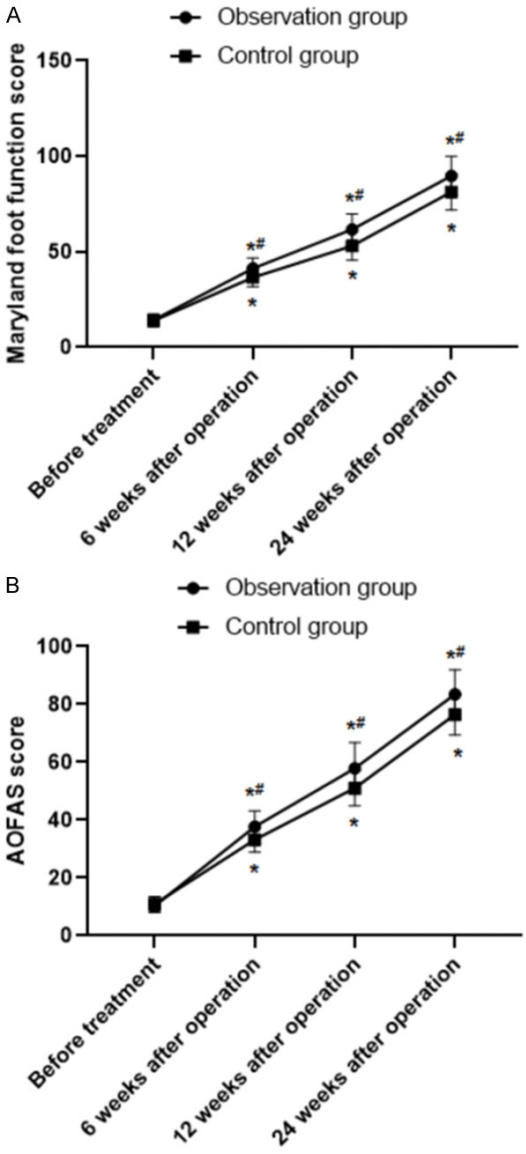

Figure 1. Comparison of Maryland foot function score and AOFAS scores between the two groups before and after treatment. Note: (A) Maryland foot function score; (B) AOFAS scores. **P<0.05* compared with the same group before treatment; *#P<0.05* compared with the control group.

control group (*P<0.05*), as shown in **Table 4** and **Figure 1B**.

Comparison of Angle B'hler and Gissane between the two groups 24 weeks after operation

The difference of Angle B'hler and Angle Gissane between the two groups of patients 24 weeks after operation was statistically insignificant (*P>0.05*) (**Table 5**).

Discussion

Calcaneus fracture is one of the most common types of tarsal fractures. Most calcaneal fractures are caused by a fall from a height or a vertical impact on the heel after the foot hits the ground. Orthopedic clinicians have conducted in-depth researches on the types of calcaneal fractures, operation timing, incision positioning, and internal fixation, but there are still patients who have not achieved good rehabilitative results. In recent years, an increasing number of scholars have focused on the postoperative rehabilitative exercise on foot function recovery of patients with calcaneal fractures [9, 10]. Wound complications and postoperative recovery of joint function are two major problems in the treatment of calcaneal fractures. As we all know, anatomical reduction and rigid internal fixation are the basis for achieving ideal treatment effect, and the active rehabilitation exercise after surgery is also a crucial part that impacts the recovery of joint function [11]. The articular surfaces of calcaneus and talus, anterior, middle and heel constitute the special structure of the subtalar joint. After calcaneal fracture, the anastomosis with the surrounding small joints will be affected, and varying degrees of ankle dysfunction in ankle joint will be caused [12, 13]. The prolonged immobilization during peri-

Table 4. Comparison of AOFAS scores between the two groups before and after treatment (points, $\bar{x}$ ± sd)

Group	Number of cases	Before treatment	6 weeks postoperatively	12 weeks postoperatively	24 weeks postoperatively
Observation group	44	10.25±2.17	37.69±5.47	57.84±8.95	83.42±8.54
Control group	42	10.96±2.58	33.21±4.36	51.06±6.08	76.42±7.03
t	-	1.384	4.188	4.090	4.139
P	-	0.170	<0.001	<0.001	<0.001

Table 5. Angle B'hler angle and Gissane at 24 weeks postoperatively between the two groups

Group	Number of cases	B'hler	Gissane
Observation group	44	30.28±3.16	131.57±6.38
Control group	42	30.97±2.98	130.89±5.37
t	-	1.041	0.534
P	-	0.301	0.595

operative period may lead to capsular contracture, muscle atrophy and osteoporosis, and result in ankle stiffness, foot pain and discomfort [14]. Studies reported by other scholars [15, 16] revealed that early rehabilitative exercise could effectively reduce the postoperative wound infection and promote the recovery of ankle joint function. In addition, studies have shown that effective postoperative rehabilitation exercise can promote the regression of body swelling, and accelerate the absorption of inflammatory factors. Meanwhile, the active rehabilitation exercise can avoid the arthrogryposis of Achilles tendon, and the injuries to the motion range of important adjacent joints in each axis caused by adhesion of ankle joint, and provide a good basis for the recovery of patient's postoperative functions [17, 18].

In recent years, there is still a great controversy about whether to carry out early weight-bearing rehabilitative exercise for calcaneal fractures with articular surface damage. Some scholars held that early weight-bearing exercise after calcaneal fracture may increase the risk of collapse of the subtalar articular surface. Others shared that early weight-bearing exercise will not cause the displacement of fractures and affect the stability of internal fixation, but can promote the postoperative functional recovery of patients and reduce the risk of osteoporosis [19-21]. In this research, the effects of early partial weight-bearing rehabilitative exercise on postoperative recovery of Sanders IV calcaneal fractures were analyzed.

The study demonstrated that the foot function of the observation group was remarkably superior to that of the control group after 24 weeks of treatment. The improvement of Maryland foot function scores and the AOFAS scores of the observation group 6 weeks, 12 weeks and 24 weeks after operation were substantially better than those of the control group. These results are consistent with the findings of other scholars [22, 23], suggesting that early partial weight-bearing rehabilitative exercise can effectively promote the rehabilitation of patients. The exercise is beneficial to the recovery of muscle strength and body circulation, and is also beneficial to enhancing patients' confidence in recovery of body function. In addition, the difference of Angle B'hler and Angle Gissane between the two groups of patients 24 weeks postoperation was statistically insignificant, indicating that the early partial weight-bearing rehabilitative exercise brings no impact to the fracture internal fixation and calcaneus shape of patients with calcaneal fractures.

To conclude, the early partial weight-bearing rehabilitative exercise can effectively promote the postoperative functional recovery of patients with Sander IV calcaneal fractures, and at the same time has no impact on internal fixation and calcaneus shape of patients, which is worthy popularizing in clinic.

Disclosure of conflict of interest

None.

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