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Original Article

Therapeutic effects of early and delayed minimally invasive percutaneous plate osteosynthesis surgery on distal tibial metaphyseal comminuted fracture

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Abstract: This study aims to investigate the effect of early and delayed injury minimally invasive percutaneous plate osteosynthesis on the treatment of distal tibial metaphyseal comminuted fracture. This study involved 90 patients with distal tibial metaphyseal comminuted fractures for treatment of minimally invasive percutaneous plate osteosynthesis between February 2012 and October 2014 in our hospital. According to treatment time, 90 patients were divided into early group and delayed group. Early group performed minimally invasive percutaneous plate osteosynthesis (MIPPO) surgery in early injury, delayed group performed MIPPO surgery in delayed injury. There were no differences for operation time, intra-operative bleeding, follow-up time and fracture healing time between early and delayed groups ($P>0.05$). Hospitalization time in early group (14.3±2.4 d) was significantly shorter than delayed group (19.7±3.3 d) ($t=8.878$, $P<0.05$). There were no claudication, fixation failure, nonunion and other complications in two group patients. In last follow-up, there were no significant differences for Lowa ankle score of function, pain, gait, activity between two groups ($P>0.05$). There were no significant differences for Lowa ankle rating score between early and delayed group ($t=0.636$, $P>0.05$). Soft tissue complications incidence after surgery of two groups were 4.44% and 8.89% respectively, the differences were not statistically significant ($\chi^2=0.714$, $P>0.05$). In conclusion, effect of early and delayed injury minimally invasive percutaneous plate osteosynthesis for treatment of distal tibial metaphyseal comminuted fracture and postoperative complications incidence of soft tissue were comparable. Hospitalization time was shorter for early injury treated with minimally invasive percutaneous plate osteosynthesis.

Keywords: Minimally invasive percutaneous plate osteosynthesis, early stage, delayed stage, fracture

Introduction

Distal tibial metaphyseal comminuted fracture is a complicated comminuted distal tibial metaphyseal fractures. Traditional treatment methods mainly adopt the open reduction and plate fixation, but the clinical treatment effect is not good. There are many disadvantages for the traditional treatment methods, including intra-operative striping, large trauma, heavy tissue damage, destruction of blood supply in fracture, serious interference of the internal environment, infection, delayed union and nonunion, and the other postoperative complications. Therefore, the traditional methods would be gradually replaced [1-3]. With the more and more requirement of modern medicine for the treatment of fracture, it is not only required to promote biological fixation, but also required to promote more effective protection of the body tissue and reduce the secondary damage. Minimally invasive percutaneous plate osteosynthesis (MIPPO) is one of the current clinical treatment for comminuted fracture of the surgical approaches.

The main principles of the MIPPO is to use the steel bridge plate fixation technology and under the premise of not doing open intervention to close the reduction operation. Meanwhile, avoiding the interference of the blood supply of the fracture end and preserving the continuity of the soft tissue, subsequently, the fracture healing rate and safety were greatly

improved [4-7]. At present, many scholars hold that MIPPO operation scheme should be operated after the tissue swelling (1 week after injury), also a few scholars believe that as soon as possible to take the surgery, which did not increase the incidence of postoperative complications [8, 9]. Therefore, this study would observe the effect of the early and delayed injury minimally invasive percutaneous plate osteosynthesis for the treatment of distal tibial metaphyseal comminuted fracture.

Materials and methods

Patients and inclusive criteria

This study included the distal tibial metaphyseal comminuted fractures patients between February 2012 and October 2014 in our hospital (90 cases). The present study was approved by the ethics committee of General Hospital of Jinan Military Command, Jinan, Shandong. All of the patients have been given the consents and approved this study.

All patients meet the inclusion criteria, including: ① Meet the AO/ASIF-43 A3 type fracture criteria; ② According to the Neer classification [10], all of the patients were diagnosed as type III or type IV fracture, both of which belong to the comminuted fracture; ③ X-ray and bone mineral density test showed moderate and severe OP changes, all fractures were the fresh closed fracture; ④ Unilateral distal tibial fractures with fractures of the distal part of the fibula; ⑤ MIPPO treatment technology. Exclusive criteria: ① Open fractures, pathological fractures, or other fractures damage of the Ipsilateral or contralateral limb; ② Consciousness disorders, combined with cerebral infarction, severe internal disease and a history of joint disease; ③ Combine the internal disease which could increase the risk of peri-operative complications.

Trial grouping

Based on the different operative time, 90 patients with distal tibial metaphyseal comminuted fracture were divided into two groups, including early group and delayed group (45 patients for each group). Early stage group was assigned as treating with minimally invasive percutaneous plate osteosynthesis in the early injury. The operation time was within 12 h after injury. This group includes 25 male and 20 female, and with the average age of 38.2±17.7 years. Injury causes were traffic accident 18 cases, falling injury 27 cases, respectively. According to the closed fracture Tscherne soft tissue injury classification [11], the patients were divided into grade I (24 cases), grade II (18 cases) and grade III (3 cases).

The delayed stage group was assigned as treating with closed reduction and external fixator or cast fixation, after the soft tissue swelling subsided, and then receiving the minimally invasive percutaneous plate osteosynthesis in delayed injury. The operation time of the patients was 5 to 12 days after injury. The group includes 12 male and 24 females, and with the average age of 39.5±15.3 years. Injury causes were traffic accident 19 cases, falling injury 26 cases, respectively. According to the Tscherne soft tissue injury classification [11], the patients were divided into grade I (26 cases), grade II (18 cases) and grade III (1 case).

Treatment method

Pre-operation: The patients in two groups were treated by the same surgeons who operated the combined spinal epidural anesthesia surgery. Early and delayed group patients were given the same treatment, except the operation time.

Intra-operation: Patients were in supine position, based on the length of shank and fracture line, chose appropriate steel plate length, between the front of medial malleolus and great saphenous vein, incised about 3 cm, zoned to the periosteum, after slightly stripping. Then, placed the steel plate to the distaltibial, and incised percutaneously about 2 cm to expose the proximal end of steel plate. Under the C-arm machine perspective traction, reset the fracture of broken end and corrected the shortening and angular deformity. For the patients with reset difficultly, placed percutaneous Kirschner wire to assist reduction. After achieved the functional reduction requirements, the far and near end of steel plate were placed with a 1 Kirschner wire, respectively, to temporarily fix the plate, after continuous traction. Both end of the plate were

Table 1. Compared the general clinical material of the two groups

Group	Early stage group (n=45)	Delayed stage group (n=45)	t or χ^2	P
Gender ratio (male/female)	25/20	24/18	0.045	0.832
Age (years)	38.2±17.7	39.5±15.3	0.373	0.355
Injury causes				
Traffic accident	18	19	0.046	0.830
Fall injury	27	26		
Soft tissue injury grading				
I grade	26	13	7.908	0.019
II grade	18	29		
III grade	1	3		

placed 1 screw, respectively, to fixation, after the X-ray examination satisfied with reduction. Both sides of the plate through incision or percutaneous placed into 3 screws, and the incision was closed after placing drainage.

Post-operation: Conventional antibiotics treated 3 d, and subcutaneously injected low-molecular-weight heparin calcium 2500 U, continued 10 d. Three days after surgery, drainage was extracted and joint initiatively exercise. One month after surgery, based on the fracture healing condition, progressively carried on the weight training until fracture healing. Follow up for 3 months, evaluated and recorded the recovery of limb function and fracture healing condition.

Observation indicator

The operation time, intrao-perative blood loss, hospitalization time, fracture healing time and complications between the two groups were observed and compared.

At the time of last follow-up, the Lowa ankle score [12] was used to evaluate the treatment effect. The project includes 4 aspects, including function, pain, gait and activity. The X-ray was reviewed to estimate the reduction maintenance and the aligned the line situation.

Statistical analysis

The statistical software SPSS17.0 was used in data statistics analysis. The calculated data were expressed as the mean ± SD, and all were compared by normality test. Student's t test was used to compare the data between the two groups. Count data were also analyzed by using Chi square test or Wilcoxon rank-sum test and the significant level was α=0.05.

Results

Comparison for basic characteristics and injuries in two groups

The results indicated that there was no significant differences (**Table 1**, P>0.05) for the gender, age and cause of injury between the two groups. However, the soft tissue injury grading between two groups showed significant difference (**Table 1**, P<0.05).

General case comparison in two groups

There were no significant differences for the intra-operative blood loss, operation time, follow-up time and fracture healing time between the early and delayed stage group (**Table 2**, P>0.05). The hospitalization time of early stage group (14.3±2.4 d) was shorter significantly compared to the delayed group (19.7±3.3 d) (**Table 2**, t=8.878, P<0.05).

Efficacy evaluation of two groups

During the follow-up period, the two group patients had no claudication, fixation failure, nonunion and other complications. In the last follow up, there were no significant differences for the Lowa ankle score of function, pain, gait, activity between the two groups (P>0.05). The Lowa ankle rating score of early and delayed group were 87.3±7.1 and 88.2±6.3, respectively. There were no significant differences between the two groups (**Table 3**, t= 0.636, P>0.05).

Review X-ray results and adverse reactions

X-ray review results showed that through X-ray evaluation, patients in the two groups appeared internal and external angle or anterior and posterior angle more than 5 degrees.

During the follow up, early group appeared incision peripheral superficial inflammation in 1 patient, after dressing treatment timely. The inflammation was well controlled and I stage

Table 2. General case comparison ($\bar{x}\pm s$)

Group	Cases No.	Operation time (min)	Intraoperative bleeding amount (ml)	Hospitalization time (d)	Follow up time (mon)	Fracture healing time (d)
Early stage	45	55.6±14.5	202.5±29.5	14.3±2.4	12.2±3.3	5.3±3.4
Delayed stage	45	55.7±15.2	201.4±30.4	19.7±3.3	13.1±3.2	6.2±3.3
t		0.032	0.016	8.878	1.313	1.274
P		0.487	0.494	0.000	0.096	0.103

Table 3. Compare the Lowa ankle score in the last follow up ($\bar{x}\pm s$, grade)

Group	Cases No.	Function (40)	Paints (40)	Gait (10)	Activity (10)	Total score (100)
Early stage	45	35.3±2.9	36.5±2.4	8.3±1.3	8.1±1.3	87.3±7.1
Delayed stage	45	35.8±3.1	37.2±2.7	8.2±1.5	8.3±1.2	88.2±6.3
t		0.790	1.300	0.338	0.758	0.636
P		0.216	0.099	0.368	0.225	0.263

was healed and took out stitches. Furthermore, 3 patients in delayed group developed distal tibia incision peripheral superficial inflammation, after dressing treatment timely. The inflammation was also controlled, but some wound were not healed, and edge of the steel plate was exposed, which may be caused by the forward position of plate placement. However, the fracture healing process of the patient was not affected. Six months after operation, fracture was healed and internal fixation was removed, Meanwhile, the would was healed well finally.

As for the adverse reaction of the two groups, 1 patient in each group developed deep incision and delayed type infection. Nevertheless, the infection was controlled after debridement drainage and antibiotics treatment, and fracture healing was not affected. The soft tissue complication incidence after surgery in early and delayed group was 4.44% and 8.89%, respectively. The difference between two groups was not statistically significant (χ^2= 0.714, P>0.05).

Discussion

Nowadays, people gradually realize the shortages of traditional open reduction and plate fixation for treating distal tibial metaphyseal comminuted fracture. The shortages of huge traumatic, high complication rate of postoperative soft tissue and low fracture healing rate, limit the clinical application of open reduction and plate fixation technique [13-15].

For the treatment of distal tibial metaphyseal comminuted fracture, minimally invasive percutaneous plate osteosynthesis has become one of the most commonly used surgery methods by orthopedist, especially for the metaphyseal comminuted fracture. The plate bridging fixation is benefit for the maintenance of fracture ending the blood supply, which could minimize the injury of soft tissue of fracture and promote fracture healing.

For A3 type of distal tibial fractures, since the injury is at the early stage of fracture, the soft tissue swelling and local inflammation reaction are also obvious. What's more, the distal tibial subcutaneous tissue is weak and blood supply is poor [16]. Consequently, the risk of soft tissue complication rate would be increased in the early internal fixation operation. Therefore, most clinicians considered that such patients should receive minimally invasive percutaneous plate osteosynthesis treatment when their soft tissue swelling reduce and skin appear fold [17].

There are also some scholars in clinical practice, who found the effects between early and delayed injury receiving the treatment of minimally invasive percutaneous plate osteosynthesis. And the incidence of complications had no obvious difference, which suggests that it's feasibility for the minimally invasive percutaneous plate osteosynthesis treatment in early stage [18].

In the early stage of fracture, because of the serious soft tissue swelling and local inflammatory reaction, the distal tibia subcutaneous

tissue is thinner and blood supply is poor. Therefore, the risk of early internal fixation surgery operation for the treatment of A3 type distal tibial fractures is likely to increase the probability of soft tissue complications.

Therefore, at present, many clinical scholars believe that the minimally invasive percutaneous plate osteosynthesis for the treatment of this kind of fracture is available and feasible [19, 20]. The advantage of MIPPO fixation methods in early injury mainly illustrated as the patient does not develop serious postoperative complications. While the reduction of early fracture is easy, often it could achieve a better on line through simple traction.

In this study, patients in the two groups received the treatment of minimally invasive percutaneous plate osteosynthesis in different time, and both groups with the well healing. During the follow up period, there were no claudication, fixation failure, nonunion and other complications appeared, and the ankle joint had a well recovery. This indicates that the surgery has a better effect whenever operate it for the treatment of distal tibial metaphyseal comminuted fracture.

There was no significant differences in gender, age and injury cause between the two groups, whereas compared with the grading of soft tissue injury, the grade I injury proportion of early surgical patients was higher than that of delayed surgical patients. In addition, the proportion of grade II and III was significantly lower, which indicated that it had been classified when chose the surgery scheme based on the general soft tissue injury condition. It means that patients are suitable for early stage surgery had less serious soft tissue injury, therefore, the incidence rate of postoperative complications in the two groups is not statistically significant ($P>0.05$).

Compared with the delayed stage, the advantage of early stage receiving minimally invasive percutaneous plate osteosynthesis was that it shortened the hospitalization time, further reduced the cost of patients. On the other aspects, though the intrao-perative bleeding between two groups had no statistically significances, the results showed that the intra-operative bleeding was more in early surgery, which is associated with the local swelling and severe wound bleeding. What's more, the counterpoint was relatively easy in early fracture surgery and would not develop the organization of hematoma or granulation tissue growth in delayed stage surgery which would delay the surgery time.

In conclusion, the effects of minimally invasive percutaneous plate osteosynthesis treatment for early and delayed injury and postoperative complication incidence of soft tissue were comparable. Besides compared with delayed injury, the hospitalization time of early injury treated with minimally invasive percutaneous plate osteosynthesis was shorter.

Disclosure of conflict of interest

None.

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