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Original Article

Minimally invasive treatment of medial malleolus fracture by implanting a hollow screw under C-arm X-ray

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Abstract: This study is to investigate the efficacy of the minimally invasive implantation, which is a domestic hollow screw for treatment of medial malleolus fracture assisted by C-arm X-ray machine. Methods: Twenty-three patients with new onset of medial malleolus fracture admitted into our hospital from 2009 to 2013 were randomly divided into the minimally invasive group and control group. Twelve patients in the minimally invasive group received minimally invasive fixation with a hollow screw under C-arm X-ray, and 11 patients in the control group received traditional open surgical reduction and screw fixation. Results: The average hospital stay time was 6.5 ± 1.4 days in minimally invasive group, compared to control group with 12 ± 2 days. There was a significant reduced time of fracture healing in minimally invasive group with 11.8 ± 0.9 weeks, compared to control group with 15.9 ± 1.1 weeks ($p<0.05$). Furthermore, there was a significant difference for excellent rate of ankle function between minimally invasive group (91%) and control group (81%, $P<0.05$). Conclusion: Minimally invasive hollow screw implantation under C-arm X-ray for treatment of medial malleolus fracture has advantages of less trauma, shorter hospital stay, faster healing, better articular surface reduction, reliable fixation and good functional recovery, and is worth to be widely applied.

Keywords: Domestically made hollow screw, internal fixation, medial malleolus fracture, minimally invasive treatment under C-arm X-ray

Introduction

Due to the rapid development in transportation and sports, the amount of medial malleolus fracture patients has a rising trend in recent years [1]. Malleolus fractures are intra-articular fractures [2]. The treatment requires both correct anatomical reduction and reliable internal fixation in order to facilitate early postoperative functional training [3]. With the development of minimally invasive techniques, the technique of minimally invasive hollow screw implantation for treatment of medial malleolus fractures is also maturing [4]. The traditional surgical solution is open reduction and plate internal fixation. Its advantages are the ability to maximize exposure of the fracture as well as anatomic reduction and stable fixation, while the disadvantages are the need for separating and retracting the soft tissue to expose the fracture fragments during surgery, a large incision, intraoperative bleeding, soft tissue and skin damage, postoperative skin necrosis, wound infection, deep vein thrombosis and other complications [1-3]. In recent years, with the advances in imaging technology and in-depth understanding of the biomechanical properties and fracture mechanisms, minimally invasive fixation technique has become the development direction of medial malleolus fracture treatment with its unique advantages.

In this paper, Twenty-three patients with new onset of medial malleolus fracture admitted into our hospital from 2009 to 2013 were randomly divided into the minimally invasive group and control group. Twelve patients in the minimally invasive group received minimally invasive fixation with a hollow screw under C-arm X-ray, and 11 patients in the control group

Table 1. Hospital stays time and fracture healing time

	Control group	Minimally invasive group
Hospital stay time (days)	12.0 ± 2.0	6.5 ± 1.4*
Fracture healing time (weeks)	15.9 ± 1.1	11.8 ± 0.9#

*P value=0.00. Statistically significant between the two groups. #P value=0.00. Statistically significant between the two groups.

received traditional open surgical reduction and screw fixation. The results are found to be favorable by follow-up, and reported as follows.

Material and methods

General information

Twenty-three patients with new onset of medial malleolus fractures were admitted into our hospital from 2009 to 2013, and were randomly divided into the minimally invasive group and control group. The 12 cases in the minimally invasive group were treated with the technique of minimally invasive hollow screw implantation. The 11 cases in the control group received traditional open reduction surgery. Inclusion criteria: according to Ashurst and Bromer classification criteria [7], all the cases were varus (adduction) type fractures degree I. Eighteen males and 15 females, aged from 19 to 61 years old. Injury cause: 15 cases were fall injuries, 8 cases were caused by traffic accidents; Injury time was 2 h-3 d, with an average of 10 h.

Preoperative preparation

The patients underwent routine preoperative examination after admission. Any absolute surgical contraindications were ruled out. The feasibility of surgery was comprehensively assessed, and there was a system of preoperative discussion.

Surgical technique

The control group received conventional open reduction and internal fixation. For patients in the experimental group, surgery was performed under a pneumatic tourniquet after anesthesia. At first, closed reduction of the malleolus fracture was done under C-arm X-ray, and a towel clamp was used for temporary fixation. From the medial malleolus tip, the guide needle of the hollow screw was inserted in the vertical direction of the fracture line. After the proper position of the guide needle was confirmed by C-arm X-ray, a skin incision about 0.8 cm was made along the guide needle, and a hole was drilled through the guide needle with the hollow drill. Then 1 or 2 Φ3.5 mm pulling nails were screwed in along the guiding needle. A protective sleeve was used to avoid damage to the surrounding tissue when drilling. After fixation, the screw head was buried in deep tissue to mitigate local skin irritation. A suture was made at each incision.

Postoperative treatment

After surgery, the injured limb was lifted, and anti-inflammation and swelling treatment was administered. Limb muscle isometric exercise was started on the second day after surgery, and ankle joint functional exercise was started on the third day. 1 week after surgery, the patient was allowed to get out of bed and take non-weight bearing activities. 3-4 weeks later, partial weight bearing was allowed. After the film confirmed good healing of the fracture, the patient was allowed to take full weight bearing walking.

Efficacy evaluation

The patients were followed up for 2 years. Their hospital stay time, fracture healing time and ankle function scores were analyzed in both groups.

Statistical analysis

Measurement data were shown as $\bar{x} \pm S$. Mean values between different groups were compared by ANOVA. Count data between different groups were compared using X^2 test. All the data were analyzed with SPSS19.0 software. P value <0.05 was considered statistically significant.

Results

Twenty-three patients were followed up for 8 to 24 months, with an average of 13 months. None of the cases had wound infection, internal fixation loosening and fracture, and unhealing of bones. For 12 cases in minimally invasive group, fracture healing time ranged from 8 to 12 weeks, with an average 11.8 ± 0.9 weeks. In 11 patients of control group, fracture healing times were significantly longer, with average of 15.9 ± 1.1 weeks ($p<0.05$, **Table 1**).

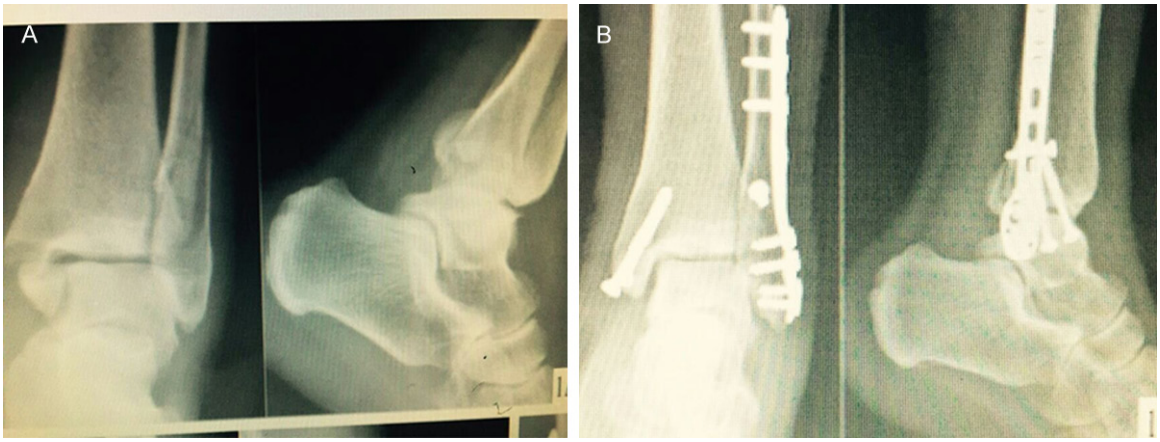

Figure 1. X-ray film taken from a patient. Male, 45 years old, medial malleolus fracture caused by fall injury, preoperative X-ray (A). X-ray film taken 3 days after surgery (B) showed that the position of the screw was satisfying.

Table 2. Ankle function evaluation*

Groups Function recover	Excellent or good (cases)	Medium (cases)
Control group	9	2*
Minimally invasive group	11	1

*In comparison between the minimally invasive group and control group, the chi-square value=4.259, P=0.039. The difference was statistically significant.

Postoperative functional evaluation was made according to Majeed criteria, including pain 30, standing situation (in which standing 40, sitting 20), and work ability 10, a total of 100. 85 to 100 was defined as excellent, 70 to 84 was defined as good, 55 to 69 was defined as medium, and <55 was defined as poor. In minimally invasive group, pain was 26.84 ± 2.90, sitting was 18.42 ± 1.66, standing was 33.68 ± 2.51, work ability was 7.68 ± 0.33, a total of 90.21 ± 8.05. 11 cases were excellent, and 1 case was good. For control group, there were 9 excellent and 2 were good. There was a significant difference for excellent rate of ankle function between minimally invasive group (91%) and control group (81%, P<0.05, **Table 2**). A typical case was shown in **Figure 1**.

The average hospital stay time was 6.5 ± 1.4 days in minimally invasive group, compared to control group with 12 ± 2 days. There was a significant reduced time of fracture healing in minimally invasive group with 11.8 ± 0.9 weeks, compared to control group with 15.9 ± 1.1 weeks (p<0.05). In comparison between the minimally invasive group and control group, the chi-square value for average hospital stay time was 4.259, with P=0.039. There was statistically significance between the minimally invasive group and control group (**Table 1**).

Discussion

The ankle joint is an important weight bearing joint of the human body. Although it has smaller articular surface area than the hip and knee joint, it bears more weight than the hip joint. And the ankle joint is close to the ground. The stress loaded on it is unable to be buffered. Plus, the articular surface of the ankle joint is thin. Therefore, joint matching and close contact of the articular surfaces are very important to prevent stress concentration and secondary degeneration [4]. Poor match of the articular surfaces, widening or narrowing of the ankle cave will cause weight bearing pain, joint instability or loosening, or limited mobility, which will further lead to traumatic arthritis in the future. Therefore there are strict requirements on treatment of ankle joint fractures. Standards of anatomical reduction should be met [5].

Minimally invasive surgery is the trend of development in modern surgery. Its research, application and popularization in in the field of traumatic orthopedics reflect the development of modern orthopedic fixation technology [6]. The technique of minimally invasive hollow screw implantation under C-arm X-ray has obvious advantages over conventional open surgery. Firstly, closed reduction of the medial malleolus fracture under C-arm X-ray with minimally invasive hollow screw implantation and fixation avoids surgical incision to expose the fracture

end. There is no further peripheral soft tissue damage, which favors fracture healing and ankle joint stability. Secondly, the technique of closed reduction and minimally invasive hollow screw fixation is easy to perform, less invasive, and causes fewer complications, reflecting the advantages of minimally invasive treatment. Furthermore, the fixation is stable and it has good tissue compatibility compared to absorbable materials. And the fixation is strong enough for early functional exercises as well as good ankle function recovery.

Results in this study show that minimally invasive hollow screw implantation under C-arm X-ray for treatment of medial malleolus fracture has obvious advantages over conventional open surgery in terms of average hospital stay time, fracture healing time, and excellent rate of ankle function score. Minimally invasive surgical treatment of medial malleolus fracture under C-arm x-ray is related with less trauma, shorter hospital stay, faster healing, good articular surface reduction, reliable fixation, early rehabilitation, and good functional recovery. It is a new clinical technology worthy of further promotion.

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Disclosure of conflict of interest

None.

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