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Original Article

Percutaneous compression cannulated screw fixation for ankle fractures

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Abstract: Objective: To dissect the efficacy of percutaneous compression cannulated screw fixation in the treatment of ankle fractures. Methods: From January 2014 to June 2016, 100 patients with unilateral ankle fractures admitted to the Department of Orthopedics of our hospital were recruited as participants in this study. They were randomly assigned by a random number table to the experiment group or the control group, with 50 cases in each group. The patients in the experiment group received percutaneous compression cannulated screw fixation, while those in the control group underwent open reduction and internal fixation. Intraoperative blood loss, operation duration, the time to initiate restricted weight-bearing ambulation and hospitalization of the patients were compared between the two study groups. Regular postoperative follow-up visits were performed for assessment of the fracture healing rate, healing duration and the rates of complications; at 1 year after operation, the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale was employed to evaluate the recovery of ankle functions. Results: The intraoperative blood loss, operation duration, the time to begin restricted weight-bearing ambulation and hospitalization were more markedly improved in the experiment group than in the control group (All $P<0.05$); the fracture healing rate and mean fracture healing duration were remarkably different ($P<0.05$); the rate of postoperative complications was significantly lowered in the experiment group (8% vs 26%, $P<0.001$). At 1 year after operation, the results of the AOFAS Ankle-Hindfoot Scale manifested the proportion of the patients with good or excellent postoperative ankle recovery was greater in the experiment group (88%) than in the control group (72%) ($P=0.046$). Conclusion: Percutaneous compression cannulated screw fixation featured shorter operation duration, less intraoperative blood, shorter hospital stay, faster fracture healing, a lower rate of complications and better recovery of ankle functions than open reduction and internal fixation in the treatment of ankle fractures. Thus, it is worth of wide application.

Keywords: Ankle fracture, percutaneous compression cannulated screw fixation, open reduction and internal fixation, clinical efficacy

Introduction

Clinically, ankle fracture, a common trauma treated in the Department of Orthopedics, is mostly caused by direct or indirect violence, which poses a great threat to the health and quality of life in patients [1-3]. It is crucial to choose a proper treatment method for the rehabilitation of patients after fracture [4, 5]. Surgical treatment is the main clinical method. The conventional open reduction and internal fixation is one major method for the treatment of ankle fractures [6]. It allows full exposure, simple operation, effective reduction of the fracture site and good fixation. However, open reduction and internal fixation results in great surgical trauma and a high rate of complications [7, 8]. Therefore, to explore the best surgical method is still the hotspot of studies on ankle fracture.

Percutaneous cannulated compression screw fixation is an effective fixation method for limb fractures and an emerging internal fixation in recent years [9, 10]. Due to its small trauma and other advantages, it is widely used in clinical practice. However, few reports have been involved in the differences in the clinical efficacy between percutaneous cannulated compression screw fixation and conventional open reduction and internal fixation in the treatment of ankle fractures. The current study was designed to analyze and compare the clinical efficacy of percutaneous cannulated compres-

Table 1. Comparison of general data of the patients between the two treatment groups

Variable	Experiment group	Control group	t/χ^2	P
Case	50	50		
Male/Female (n)	30/20	35/15	1.099	0.295
Age (year)	36.4±3.9	34.0±2.6	0.887	0.425
Ankle fracture (Right/left, n)	28/22	32/18	0.667	0.414
Cause of injury (n)				
Traffic injury	22	23	0.914	0.633
Sports injury	10	13		
Fall injury	18	14		
Weber-AO fracture type				
Type A	10	9	0.980	0.613
Type B	32	36		
Type C	8	5		
Time from injury to surgery (h)	8.7±1.2	11.9±1.7	2.664	0.056

sion screw fixation and that of conventional open reduction and internal fixation in the treatment of ankle fractures, and to lay an experimental basis for the treatment of ankle fractures.

Materials and methods

General data

From January 2014 to June 2016, a total of 100 patients with unilateral ankle fractures admitted to the Department of Orthopedics in our hospital were enrolled as subjects. All the enrolled patients signed written informed consent and this study was approved by the Hospital Ethics Committee. The patients older than 18 years old were included in this study if they had no history of ankle fracture, and had newly-closed fracture as confirmed by clinical symptoms and imaging review. Patients were excluded if they had contraindications to or were unwilling to receive spinal anesthesia, had severe organ dysfunctions in the liver or the kidney, open fracture, comminuted fracture, pathological fracture, contraindications to surgery associated with coagulopathy or were unable to follow in this study. One hundred patients were randomly assigned to the experiment group (n=50) or the control group (n=50). The patients in the experiment group were treated with percutaneous cannulated compression screw fixation, whereas those in the control group were given open reduction and internal fixation.

Methods

Open reduction and internal fixation: Under spinal anesthesia, the patient was given routine disinfection and draping. Then an incision was made at the site depending on lateral or medial malleolus ankle fractures. An incision for lateral malleolus ankle fracture was made starting from the anterior margin of the lower fibula bone to the lower lateral malleolus, whereas an incision for medial malleolus ankle fracture was made starting from the anterolateral medial malleolus to the distal medial malleolus. The flaps of skin were separated to expose the fracture positions, followed by clearance of hematoma, soft tissues at the ends of the fracture and the debris in the joint cavity. The fracture fragments were reset with the use of towel forceps, with small fragments fixed with Kirschner wires and big fractures fixed with screws. Good reduction of the fractures were confirmed by a C-arm device, followed by incision layered-suturing and compressive bandaging, with concomitant external plaster casting.

Percutaneous cannulated compression screw fixation: With the patients under spinal anesthesia, manual traction reduction or poking reduction was performed on them in the order of medial, lateral and posterior malleolus ankle fractures under the guidance of C-arm fluoroscopy, so that the fracture sites were close to or in full compliance with the conditions of anatomical reduction. When the ankle articular surface was flattened, a Kirschner wire of 8 mm was inserted for fixation. Subsequently, along the Kirschner wire, some proper compression cannulated screws were implanted inside the fractures for internal fixation. Good reduction of the fractures were confirmed by a C-arm device, followed by incision layered-suturing and compressive bandaging, concomitant with external plaster casting.

Outcome measures

Primary outcome was the fracture healing rates of the two groups. The patients received follow-up radiography to examine the fracture healing rates within 3 months after surgery. The

Table 2. Comparison of intraoperative blood loss, operation duration, the time to initiate restricted weight-bearing ambulation and hospital stay between the two groups

Variable	Case (n)	IBS (mL)	OD (min)	TILWBA (week)	HS (d)
Experiment group	50	17.5±3.7	43.7±8.5	6.4±1.6	8.9±1.8
Control group	50	50.4±4.5	70.1±12.8	9.5±1.9	13.6±2.2
t		9.781	2.976	2.776	3.696
P		0.001	0.041	0.027	0.008

Note: IBS denotes intraoperative blood loss; OD Operation duration; ILWBA time to initiate restricted weight-bearing ambulation; HS hospital stay.

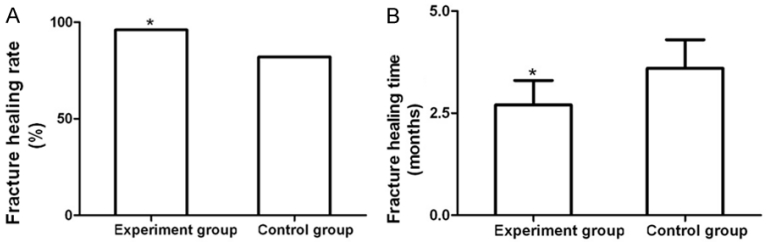

Figure 1. Comparison of fracture healing rate and healing duration between the two groups, compared with the control group, *P<0.05; A: Fracture healing rate; B: Fracture healing duration.

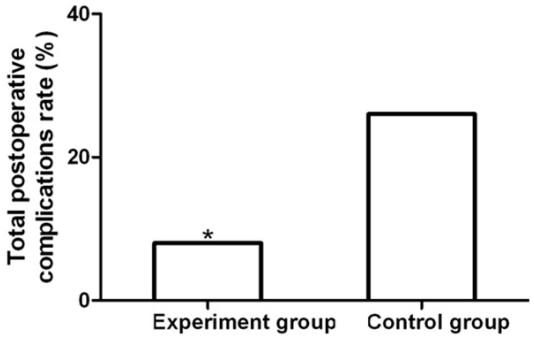

Figure 2. The total postoperative complications rates in the two groups, compared with the control group, *P<0.05

American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale was applied to assess the recovery of ankle functions at 1 year after operation. Scores range from 1 to 100 points, with more than 90 points indicating excellent outcome, 75 to 89 good outcome, 60 to 74 fair outcome, and less than 60 poor outcome. The proportion of patients with good or excellent postoperative ankle recovery was compared between the two groups.

Secondary outcomes included intraoperative blood loss, operation duration, the time to initiate restricted weight-bearing ambulation, hospital stay, fracture healing duration and the rate of complications of the patients, all of which were compared between the two groups.

Statistical analysis

All data were analyzed using the SPSS software, version 2.0. Measurement data were presented as mean ± standard deviation, with the independent sample t-test utilized for between-group comparisons. Enumeration data were expressed as percentages, with the chi-square test applied for between-group comparisons. P<0.05 was considered significantly different.

Results

Patient characteristics

Of the 100 eligible patients, 65 were male, and 35 were female, with a mean age of 35.2±3.7 years. Left ankle fracture occurred in 60 patients and right ankle fracture in 40. Traffic injury was present in 45 patients; sports injury in 23 patients; fall injury in 32 patients, with the mean time from injury to surgery of (10.3±1.5) h. Nineteen patients had Weber-A0 fractures of Type A; 68 had Weber-A0 fractures of B type; 13 had Weber-A0 fractures of Type C. The general data of patients including gender, age, right or left ankle fractures, the causes of injury, the time from injury to surgery and fracture type were generally well balanced between the groups (P>0.05), so they were comparable (**Table 1**).

Intraoperative blood loss, operation duration, the time to initiate restricted weight-bearing ambulation and hospital stay

The patients in the experiment group had intraoperative blood loss of (17.5±3.7) mL, the operation duration of 43.7±8.5 min, the time to initiate restricted weight-bearing ambulation of 6.4±1.6 weeks and hospital stay of 8.9±1.8 days. Greater improvements in intraoperative blood loss, operation duration, the time to initiate restricted weight-bearing ambulation and

Table 3. Comparison of AOFAS Ankle-Hindfoot score between two groups

Group	Case	AOFAS Ankle-Hindfoot score				Proportion of the patients with good or excellent recovery
		Excellent	Good	Fair	Poor	
Experiment group	50	35	9	4	2	88.0*
Control group	50	19	17	11	3	72.0

Note: *P<0.05 for the comparison between the experiment group and with the control group

hospital stay of the patients were observed in the experiment group patients than in the control group (All P<0.05, **Table 2**).

Fracture healing rate and duration

The fracture healing occurred in 96% (mean healing duration, 2.7±0.6 months) of the patients in the experiment group and 82% (mean healing duration, 3.6±0.7 months) in of the patients in the control group. The rates (χ^2=5.369, P=0.020) and the mean duration of fracture healing (t=2.319, P=0.037) differed markedly between the two groups (Both P<0.05, **Figure 1**).

Postoperative complications

Of 50 patients in the experiment group, no incision infection was observed; internal fixation loosening or rupture occurred in 2 patients; ankle joint stiffness occurred in 2, with 8% of the patients having postoperative complications; of 50 patients in the control group, incision infection occurred in 3 patients; internal fixation loosening or rupture occurred in 4; ankle joint stiffness occurred in 6, with 26% of the patients having postoperative complications. The rate of total postoperative complications in the experiment was substantially different from that of the control group (χ^2=14.439, P=0.000; **Figure 2**).

The proportion of patients with good or excellent postoperative ankle recovery

At 1-year follow-up after surgery, among the 50 patients in the experiment group, 35 had excellent postoperative ankle recovery and 9 had good recovery, with 88.0% of them achieving good or excellent postoperative ankle recovery; among the 50 patients in the control group, 19 had excellent postoperative ankle recovery and 17 had good recovery, with 72% of them achieving good or excellent postoperative ankle recovery. The proportion of patients with good or excellent postoperative ankle recovery in the experiment group was greater than that of the control group (χ^2=4.000, P=0.046), as shown in **Table 3**.

Discussion

The ankle joint is a weight-bearing joint, primarily composed of the talus and the lower end of the tibia and fibula. A common ankle fracture is the intra-articular fracture. Poor reduction of ankle fracture tends to result in traumatic ankle arthritis in patients, with numb, stiff and painful ankle, or even difficulty in ambulation. Therefore, a good understanding of the anatomic principle with regard to recovery of the fractured ankle joint to normal state in the treatment of ankle fracture is essential to promote healing and functional recovery of the fractured ankle [11].

Currently, open reduction and internal fixation is a common technique for treating ankle fracture, which has been accepted by a large number of clinicians. Nevertheless, the results from multiple follow-up studies indicate that open reduction and internal fixation still has such disadvantages as large incisions and postoperative scar hypertrophy affecting the appearance of the fractured limbs; damages to the soft tissues around the fracture sites and to the rich vascular network on the periosteum, which is prone to the complications including exposure of the internal fixation and wound infection; prolonged time to ambulation, which is not conducive to callus formation and postoperative recovery [12-16]. As a result, the technique is hard to accept among patients in recent years. Percutaneous compression cannulated screw fixation is a newly-developed minimally invasive surgery. Under the guidance of C-arm fluoroscopy, the fracture of the patient was firstly treated with the use of manipulative reduction and then cannulated screws were percutaneously implanted for internal fixation. This protocol integrates the advantages of both closed reduction and external fixation and open reduction and internal fixation, and overcomes the disadvantages of the two techniques. Additionally, it minimizes secondary damages to

the soft tissues surrounding the fracture site, promoting the healing of ankle fracture. Percutaneous compression cannulated screw fixation is a preferred technique for patients with severe local contusion, poor physical condition and intolerance to a long time surgery. However, the technique is ineffective in the treatment of old medial malleolus fractures including vertical compression and comminuted medial condyle fractures [17]. It is noted that percutaneous compression cannulated screw fixation has a strict requirement for the clinician to have a good understanding of the indications to the treatment. For the patients with ankle fractures, the proper surgical method should be chosen based on their respective fracture types.

In the current study, we enrolled 100 patients with unilateral ankle fractures to compare the clinical efficacy of open reduction and internal fixation and percutaneous compression cannulated screw fixation in the treatment of ankle fractures. The findings of the study indicated that greater improvements in intraoperative bleeding, operation duration, the time to initiate restricted weight-bearing ambulation, hospital stay and fracture healing duration, a higher fracture healing rate, a lower rate of postoperative complications and a larger proportion of patients with good or excellent postoperative ankle recovery were noted in the patients with percutaneous compression cannulated screw fixation as compared with those with open reduction and internal fixation. The above results are basically consistent with those reported by Weinraub et al. and Barnes H et al. [18, 19]. According to another study, in the treatment of patients with medial malleolus fractures, closed reduction and internal fixation was associated with better and earlier postoperative ankle functional recovery than open reduction and internal fixation [20]. This study suggests that percutaneous compression cannulated screw fixation is more effective than open reduction and internal fixation, which may be due to the small incision which precludes extensive periosteal stripping and damages to the blood supply at the fracture site. All this minimized the surgery-induced trauma. In addition, the use of pressurizing cannulated screws at the broken end increased the torsional and shear strength and ensured stability of internal fixation, which is contribute to the implementation of earlier functional exercise in patients [21, 22].

In conclusion, percutaneous compression cannulated screw fixation and open reduction and internal fixation were employed for clinical treatment of ankle fractures, but the former was associated with smaller trauma, a lower rate of complications, and a more active role in early function recovery in the ankles of patients. However, there are some limitations in this study, such as a single center study, a small sample size, short follow-ups, as well as inability to confirm the long-term outcomes of the above surgical techniques in treatment of ankle fractures. Additional studies warrant for further validation.

Disclosure of conflict of interest

None.

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References

[1] Goost H, Wimmer MD, Barg A, Kabir K, Valderrabano V and Burger C. Fractures of the ankle joint: investigation and treatment options. Dtsch Arztebl Int 2014; 111: 377-388.

[2] van Zuuren WJ, Schepers T, Beumer A, Sierevelt I, van Noort A and van den Bekerom MPJ. Acute syndesmotic instability in ankle fractures: a review. Foot Ankle Surg 2017; 23: 135-141.

[3] Toth MJ, Yoon RS, Liporace FA and Koval KJ. What's new in ankle fractures. Injury 2017; 48: 2035-2041.

[4] Yeung DE, Jia X, Miller CA and Barker SL. Interventions for treating ankle fractures in children. Cochrane Database Syst Rev 2016; 4: Cd010836.

[5] Rammelt S. Management of ankle fractures in the elderly. EFORT Open Rev 2016; 1: 239-246.

[6] Sun R, Li M, Wang X, Li X, Wu L, Chen Z and Chen K. Surgical site infection following open reduction and internal fixation of a closed ankle fractures: a retrospective multicenter cohort study. Int J Surg 2017; 48: 86-91.

[7] White TO, Bugler KE, Appleton P, Will E, McQueen MM and Court-Brown CM. A prospective randomised controlled trial of the fibular nail

versus standard open reduction and internal fixation for fixation of ankle fractures in elderly patients. Bone Joint J 2016; 98-b: 1248-1252.
[8] Schairer WW, Nwachukwu BU, Dare DM and Drakos MC. Arthroscopically assisted open reduction-internal fixation of ankle fractures: significance of the arthroscopic ankle drive-through sign. Arthrosc Tech 2016; 5: e407-412.
[9] Kim MB, Lee YH, Kim JH, Lee JE and Baek GH. Lateral transmalleolar approach and minis-crews fixation for displaced posterolateral fragments of posterior malleolus fractures in adults: a consecutive study. J Orthop Trauma 2015; 29: 105-109.
[10] Smith M, Medlock G and Johnstone AJ. Percutaneous screw fixation of unstable ankle fractures in patients with poor soft tissues and significant co-morbidities. Foot Ankle Surg 2017; 23: 16-20.
[11] Qin C, Dekker RG, Blough JT and Kadakia AR. safety and outcomes of inpatient compared with outpatient surgical procedures for ankle fractures. J Bone Joint Surg Am 2016; 98: 1699-1705.
[12] Zwipp H, Rammelt S, Endres T and Heineck J. High union rates and function scores at mid-term followup with ankle arthrodesis using a four screw technique. Clin Orthop Relat Res 2010; 468: 958-968.
[13] Lovy AJ, Dowdell J, Keswani A, Koehler S, Kim J, Weinfeld S and Joseph D. Nonoperative versus operative treatment of displaced ankle fractures in diabetics. Foot Ankle Int 2017; 38: 255-260.
[14] Gonzalez TA, Macaulay AA, Ehrlichman LK, Drummond R, Mittal V and DiGiovanni CW. Arthroscopically assisted versus standard open reduction and internal fixation techniques for the acute ankle fracture. Foot Ankle Int 2016; 37: 554-562.
[15] Bariteau JT, Hsu RY, Mor V, Lee Y, DiGiovanni CW and Hayda R. Operative versus nonoperative treatment of geriatric ankle fractures: a medicare part a claims database analysis. Foot Ankle Int 2015; 36: 648-655.
[16] Pires RE, Mauffrey C, de Andrade MA, Figueiredo LB, Giordano V, Belloti JC and dos Reis FB. Minimally invasive percutaneous plate osteosynthesis for ankle fractures: a prospective observational cohort study. Eur J Orthop Surg Traumatol 2014; 24: 1297-1303.
[17] Casstevens C, Le T, Archdeacon MT and Wyrick JD. Management of extra-articular fractures of the distal tibia: intramedullary nailing versus plate fixation. J Am Acad Orthop Surg 2012; 20: 675-683.
[18] Weinraub GM, Levine P, Shi E and Flowers A. Comparison of medial malleolar fracture healing at 8 weeks after open reduction internal fixation versus percutaneous fixation: a retrospective cohort study. J Foot Ankle Surg 2017; 56: 277-281.
[19] Barnes H, Cannada LK and Watson JT. A clinical evaluation of alternative fixation techniques for medial malleolus fractures. Injury 2014; 45: 1365-1367.
[20] Sagi HC, Shah AR and Sanders RW. The functional consequence of syndesmotic joint malreduction at a minimum 2-year follow-up. J Orthop Trauma 2012; 26: 439-443.
[21] Cicekli O, Ozdemir G, Uysal M, Bicici V and Bingol I. Percutaneous cannulated screw fixation for pediatric epiphyseal ankle fractures. Springerplus 2016; 5: 1925.
[22] Saini P, Aggrawal A, Meena S, Trikha V and Mittal S. Miniarthrotomy assisted percutaneous screw fixation for displaced medial malleolus fractures- a novel technique. J Clin Orthop Trauma 2014; 5: 252-256.