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Comparison of different treatment methods for supination-lateral rotation ankle fractures

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ABSTRACT

Objectives: This study aims to compare the therapeutic effects of fixation with fibular approach, fixation with posterolateral fibular approach, and conservative therapy on supination-lateral rotation ankle fractures.

Patients and methods: A total of 189 patients (103 males, 86 females; mean age: 45.7±4.7 years; range, 40 to 51 years) with supination-lateral rotation ankle fractures treated in our hospital between March 2020 and March 2021 were included in this prospective study. The patients were assigned into conservative therapy, fibular approach, and posterolateral approach groups including 63 patients in each group. Clinical conservative therapy was performed for conservative therapy group, while fibular approach and posterolateral approach groups were given fixation with fibular approach and posterolateral fibular approach, respectively. Their routine parameters, body stress, ankle function, treatment efficacy and safety were compared.

Results: The length of hospital stay was shorter in the fibular approach and posterolateral approach groups than the conservative therapy group, particularly in the fibular approach group ($p<0.05$). The pain stress and oxidative stress were lower in the fibular approach and posterolateral approach groups than the conservative therapy group, particularly in the posterolateral approach group ($p<0.05$). Compared to the conservative therapy group, the fibular approach and posterolateral approach groups had significantly recovered ankle function, with better recovery in the posterolateral approach group ($p<0.05$). The response rate was higher in the fibular approach and posterolateral approach groups than the conservative therapy group, being higher in the posterolateral approach group ($p<0.05$).

Conclusion: For patients with supination-lateral rotation ankle fractures, fixation with posterolateral fibular approach is more effective for expediting the recovery of ankle joints than conservative therapy and fixation with fibular approach, accompanied by higher safety.

Keywords: Ankle fracture, conservative therapy, fibular approach, fixation, posterolateral fibular approach, supination-lateral rotation.

As common ankle fractures, supination-lateral rotation ankle fractures are able to damage the posterior, lateral, and medial malleoli of patients. In general, inferior tibiofibular syndesmotic disruption is manifested in some patients with such ankle fractures. As the ankle is a weight-bearing joint, supination-lateral rotation ankle fractures not treated in time would affect the recovery of ankle function, making the daily life of patients inconvenient.[1-3] Stress injuries are important pathophysiological characteristics after trauma, mainly including pain and oxidative stresses.[4] Pain stress after fracture affects the hemodynamics of patients, inducing adverse events such as angina pectoris and tachycardia.[5] Additionally, oxidative stress causes microvascular damage on injured articular surfaces, affects revascularization and bone deposition, and ultimately influences bone healing.[6] Therefore, the effectiveness and safety of a treatment method have been evaluated based on stresses.[7]

Although such ankle fractures are successfully treated by conventional conservative therapy and surgery, these methods have their own merits and demerits.[8] Meanwhile, the ultimate goal of

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clinically treating supination-lateral rotation ankle fractures is not simply to realize healing, but to restore the ankle joint to a stable, painless range of motion (ROM) without increasing the stress.[9] Thus, selecting a correct treatment method is of great clinical significance to the rapid recovery of patients with fractures.

In the present study, we aimed to evaluate patients with supination-lateral rotation ankle fractures who were subjected to conservative therapy and surgery respectively, and to compare the treatment outcomes of different surgical approaches, aiming to provide a reference for the selection of therapeutic regimens in the clinical practice.

PATIENTS AND METHODS

This single-center, prospective study was conducted at Nanjing First Hospital, Nanjing Medical University, Department of Orthopaedic Surgery between March 2020 and March 2021. A total of 189 patients (103 males, 86 females; mean age: 45.7±4.7 years; range, 40 to 51 years) with supination-lateral rotation ankle fractures treated in our hospital were included. The patients were assigned into conservative therapy group (n=63), fibular approach group (n=63), and posterolateral approach group (n=63). Inclusion criteria were as follows: patients with fresh fractures (fractures <2 weeks), those with Lauge-Hansen Stage III/IV, those diagnosed as supination-lateral rotation ankle fractures based on imaging studies, those without contraindications for surgery or surgical anesthesia, and those with non-pathological fractures. Exclusion criteria were as follows: patients with hyperglycemia, open fractures, poor compliance, or abnormalities in cognition, communication or thinking, those with stress injuries caused by smoking, diabetes mellitus and hypertension, those aged ≥60 years old, or those intolerant to surgery.

Treatment methods

In the conservative therapy group, clinical conservative therapy was performed. Specifically, patients were in the supine position and, then, the fracture line of the medial malleolus of the tibia and the lateral malleolus were pressed against forcibly to achieve fracture recombination. Meanwhile, the posterior malleolus was pulled down through the joint capsule in the state of dorsal extension of ankle to achieve the reduction of ankle bone. Following satisfied reduction, the intra-articular range and ROM were maintained with the assistance of another assistant, and immobilization was completed with a plaster cast. Additionally, the elastic band for the external support was adjusted according to the swelling of patient limb, and patients were given anti-inflammatory and anti-swelling drugs routinely.

In the fibular approach group and posterolateral approach group, surgery was completed by the same team of physicians under epidural anesthesia. Fixation with fibular approach was carried out in the fibular approach group. Briefly, after patients were placed in the supine position, an incision was made at the posterior edge of the fibula at 12 cm from the malleolus fibulae point, serving as an approach for surgery. Then, periosteum stripping was conducted to fully expose fibular and lateral malleolus injuries. Next, some fibular tendons were dissociated, followed by dissociation of the broken end of fractures. The anterior and posterior ligaments of the fibula were, then, cut off, and the lateral malleolus was dissociated toward the distal end and inverted outwards to completely expose the fracture site and the outer side of the joint. Afterwards, reduction and fixation of the posterior, lateral, and medial malleoli were performed in sequence, with the posterior malleolus reduced from front to back with empty lag screws for fixation. In the posterolateral approach group, the patients received fixation with posterolateral fibular approach. In brief, the patients were in the prone position, and a surgical incision (10 cm) was made on the posterolateral side of the fibula. Next, the skin and fasciae were cut open to separate long peroneal muscle and the posterior edge of peroneus brevis. Afterwards, the flexor hallucis longus and the fracture site were exposed from the spaces of the short muscle and the flexor hallucis longus, followed by reduction and fixation of the posterior, lateral and medial malleoli in turn. Subsequently, fixation was performed selectively with a T-shaped plate support or cannulated screws from the posterior lateral to the anterior according to the fracture condition of patients. For patients in the fibular approach group and posterolateral approach group, routine joint capsule repair and conventional suture were carried out, postoperative indwelling drainage tubes were placed, and a routine anti-infection intervention was performed.

Assessment of routine parameters

The length of hospital stay and fracture healing time in the three groups, as well as operation duration and intraoperative blood loss in fibular approach group and posterolateral approach group, were recorded.

TABLE I
Overall data (n=63)

Group	Mean age (year)	Time from fracture to hospital admission (day)	Sex Male/Female	Lauge-Hansen classification (Stage III/IV)	Affected side (left/right)	Cause of fracture (traffic accident/ sprain/other)
	Mean±SD	Mean±SD	n	n	n	n
Conservative therapy	45.6±4.7	11.2±1.5	34/29	12/51	35/28	24/18/21
Fibular approach	45.9±4.8	11.5±1.4	36/27	15/48	33/30	27/17/19
Posterolateral approach	45.6±4.7	11.0±1.4	33/30	11/52	30/33	25/20/18

SD: Standard deviation.

Assessment of body stress

The body stress of patients was evaluated based on the levels of pain stress indexes substance p (SP), neuropeptide Y (NPY) and prostaglandin E2 (PGE2), and oxidative stress indexes superoxide dismutase (SOD), total antioxidant capacity (TAC) and catalase (CAT). A higher level indicated more severe stress of patients. Venous blood was collected from patients before treatment (after admission) and on Days 3 and 7 after treatment to separate the serum. Then, an enzyme-linked immunometric meter (Palangen) (Perlong Medical Equipment Co., Ltd., Beijing, China) and an automatic chemiluminescence analyzer (MAGLUMI 1000, Snibe Co., Ltd., Shenzhen, China) were adopted to separately measure the levels of pain stress indexes SP, NPY, and PGE2 and SOD, TAC and CAT before treatment (after admission) and on Days 3 and 7 after treatment.

Evaluation of ankle function and efficacy

After treatment, a six-month follow-up was conducted in all patients. The ankle function of patients was assessed with the Mazur score before treatment (after admission) and at one, three, and six months after treatment. The clinical efficacy was evaluated based on the score of patients at six months after treatment, which was classified into four grades [poor (≤65 points), fair (65-86 points), good (87-92 points) and excellent (≥92 points)], and the excellent and good rates were calculated.

Observation of safety

During the six-month follow-up period, the incidence of adverse events such as incision infection, fracture nonunion, and malunion were recorded.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. Univariate analysis was carried out using the Kaplan-Meier method. Inter-group analysis was performed using the F test, while the intra-group analysis was performed using the least significant difference (LSD) t-test. Analysis of variance was conducted on repeated measurements for comparison before and after treatment. Categorical data were compared using the chi-square (χ^2) test. A p value of <0.05 was considered statistically significant.

RESULTS

Routine parameters

Overall data were comparable among the three groups (Table I) (p>0.05). The length of hospital

TABLE II
Routine parameters (n=63)

Group	Length of hospital stay (day)	Fracture healing time (week)	Operation duration (min)	Intraoperative blood loss (mL)
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Conservative therapy	10.2±1.4	8.5±0.9	-	-
Fibular approach	19.0±2.4*	8.2±0.9	113.7±11.2	266.1±25.7
Posterolateral approach	14.5±2.1*#	8.1±0.9	113.0±12.0	265.5±16.0

SD: Standard deviation; * p<0.05 *vs.* conservative therapy group; # p<0.05 *vs.* fibular approach group.

TABLE III

Pain stress (n=63)

	SP (μg/mL)			NPY (pg/mL)			PGE2 (pg/mL)		
	Before treatment (after admission)	3 day after treatment	7 day after treatment	Before treatment (after admission)	3 day after treatment	7 day after treatment	Before treatment (after admission)	3 day after treatment	7 day after treatment
Group	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Conservative therapy	4.1±1.0	15.6±2.3*	8.5±0.9*	133.4±14.6	230.9±24.5*	187.9±15.4*	100.3±11.4	208.4±21.2*	164.5±12.3*
Fibular approach	4.1±0.8	12.3±1.1*&	6.6±0.8*#&	133.0±14.3	211.2±23.4*&	174.3±16.7*#&	101.1±11.5	174.5±13.5*&	142.0±15.3*#&
Posterolateral approach	4.2±0.6	10.0±1.2*&‡	5.3±0.3*#&‡	133.1±14.6	186.5±15.6*&‡	152.6±14.6*#&‡	101.0±11.3	153.3±11.1*&‡	118.5±12.3*#&‡

SP: Substance p; NPY: Neuropeptide Y; PGE2: Prostaglandin E2; SD: Standard deviation; * p<0.05 *vs.* before treatment (after admission). # p<0.05 *vs.* at 3 d after treatment. & p<0.05 *vs.* conservative therapy group. ‡ p<0.05 *vs.* fibular approach group.

TABLE IV

Oxidative stress (n=63)

	SOD (U/mL)			TAC (U/mL)			CAT (U/mL)		
	Before treatment (after admission)	3 day after treatment	7 day after treatment	Before treatment (after admission)	3 day after treatment	7 day after treatment	Before treatment (after admission)	3 day after treatment	7 day after treatment
Group	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Conservative therapy	71.5±7.3	97.8±9.0*	83.7±8.1*	11.4±1.2	31.0±3.3*	23.0±2.7*	42.3±4.6	67.9±6.3*	60.9±7.5*
Fibular approach	71.8±7.4	88.7±6.8*&	77.4±6.7*#&	11.5±1.2	25.7±2.6*&	17.9±2.2*#&	42.4±4.7	58.9±7.9*&	53.3±5.6*#&
Posterolateral approach	71.3±7.2	78.8±7.9*&‡	73.1±6.8*&‡	11.3±1.2	20.9±2.3*&‡	13.7±1.1*&‡	42.1±4.2	56.0±5.7*&‡	49.0±5.2*&‡

SOD: Superoxide dismutase, TAC: Total antioxidant capacity; CAT: Catalase; SD: Standard deviation; * p<0.05 *vs.* before treatment (after admission). # p<0.05 *vs.* at 3 d after treatment. & p<0.05 *vs.* conservative therapy group. ‡ p<0.05 *vs.* fibular approach group.

stay was shorter in the fibular approach group and posterolateral approach group than that the conservative therapy group, and it was also shorter in the fibular approach group than that the posterolateral approach group ($p<0.05$). The fracture healing time was of no statistically significant difference among the conservative therapy group, fibular approach group and posterolateral approach group ($p>0.05$). The operation duration and intraoperative blood loss showed no statistically significant differences between the fibular approach group and posterolateral approach group ($p>0.05$) (Table II).

Body stress

According to comparison of body stress, the pain stress and oxidative stress showed no statistically significant differences among the three groups ($p>0.05$). The pain stress and oxidative stress were lower in the fibular approach group and posterolateral approach group than those in conservative therapy group, and these values decreased in the posterolateral approach group compared with those in fibular approach group on Days 3 and 7 after treatment ($p<0.05$) (Tables III and IV).

Ankle function

According to comparison of ankle function, no statistically significant difference was found in the ankle function score among the three groups ($p>0.05$). In contrast with the conservative therapy group, the fibular approach group and posterolateral approach group exhibited significantly recovered ankle function at one, three, and six months after treatment, with a better recovery in the posterolateral approach group than the fibular approach group ($p<0.05$) (Table V).

Treatment outcomes

The response rate was higher in the fibular approach group and posterolateral approach group

TABLE V
Ankle function point (n=63)

Groups	Before treatment (after admission) Mean±SD	1 month after treatment Mean±SD	3 months after treatment Mean±SD	6 months after treatment Mean±SD
Conservative therapy	6.7±1.0	35.5±4.4*	55.6±6.1*#	70.8±6.5*#&
Fibular approach	6.8±1.1	44.3±5.0*†	68.8±7.2*#†	80.9±8.4*#&†
Posterolateral approach	6.9±1.0	56.7±5.6*†‡	75.4±7.1*#†‡	94.5±4.4*#&†‡

* $p<0.05$ *vs.* before treatment (after admission). # $p<0.05$ vs. at 1 month after treatment. & $p<0.05$ *vs.* at 3 months after treatment. † $p<0.05$ *vs.* conservative therapy group. ‡ $p<0.05$ *vs.* fibular approach group.

TABLE VI
Treatment outcomes (n=63)

Groups	Excellent n	Good n	Fair n	Poor n	Excellent and good rate n	Excellent and good rate %
Conservative therapy	30	14	11	8	44	69.84
Fibular approach	32	22	6	3	54*	85.71
Posterolateral approach	45	16	1	1	61*#	96.83

* $p<0.05$ *vs.* conservative therapy group; # $p<0.05$ *vs.* fibular approach group.

TABLE VII
Incidence rates of adverse events (n=63)

Groups	Incision infection n	Fracture nonunion n	Malunion n	Incidence rate of adverse events n	Incidence rate of adverse events %
Conservative therapy	-	2	3	5	7.94
Fibular approach	3	2	1	6	9.52
Posterolateral approach	0	1	1	2	3.17



FIGURE 1. Images of patients with supination-lateral rotation ankle fractures treated with fixation with fibular approach before and after surgery. **(a)** Preoperative anteroposterior and lateral position (X-ray film). **(b)** Preoperative coronal and sagittal position (CT film). **(c)** One month after operation, anterior and lateral position (X-ray film). **(d)** Three months after operation, the anterior and lateral position (X-ray film).



FIGURE 2. Images of patients with supination-lateral rotation ankle fractures treated with fixation with posterolateral fibular approach before and after surgery. **(a)** Preoperative anteroposterior and lateral position (X-ray film). **(b)** Preoperative coronal and sagittal phosition (CT film). **(c)** One month after operation, anterior and lateral position (X-ray film). **(d)** Three months after operation, the anterior and lateral position (X-ray film).

than the conservative therapy group, and it was significantly higher in the posterolateral approach group than the fibular approach group ($p<0.05$) (Table VI).

The three groups had similar incidence rates of adverse events ($p>0.05$) (Table VII).

The case images are shown in Figure 1 and Figure 2.

DISCUSSION

Supination-lateral rotation ankle fractures mainly manifest pain at fracture sites and stability imbalance, posing a certain impact on the mind and body of patients. Currently, the selection of treatment methods has attracted widespread attention. Researches have suggested that a good therapeutic approach is capable of facilitating the recovery of joint function of patients without affecting the prognosis and daily life.[10]

Currently, supination-lateral rotation ankle fractures are mainly treated by surgery and conservative therapy in the clinical practice. In contrast with surgery, conservative therapy not requiring an operation can protect the blood supply of fracture sites to some extent, shorten the length of hospital stay, and facilitate fracture healing when applied in the treatment of patients.[11,12] Surgery treats patients through anatomical reduction and internal fixation. Several studies have manifested that, in case of supination-lateral rotation ankle fractures, the posterolateral tibia is mainly injured and, therefore, surgery with fibular approach or posterolateral fibular approach can promote the recovery of injuries to the greatest extent.[13-15] It has been reported that posterolateral fibular approach can better maintain the stability of patient ankle than fibular approach.[16] During fracture fixation and repair through the posterolateral fibular approach, the ROM and stability of ankle can be observed by clinicians, and screw fixation can be performed if poor stability is observed, to better maintain the stability of patient ankle joints.[17-19] In this study, conservative therapy and surgery with different approaches were applied to treat patients with supination-lateral rotation ankle fractures for the first time.[20] Surgery achieved superior efficacy to that by conservative therapy. The comparison of surgery with different approaches revealed that fixation with posterolateral fibular approach was better than fixation with fibular approach. These results indicate that surgery is more effective than conservative therapy for the treatment of supination-lateral rotation ankle fractures, and the selection of posterolateral fibula approach during surgery can better accelerate the functional recovery of patients.

According to a report, oxidative stress is induced by both external and internal injuries of the body, and a more severe injury indicates a more severe oxidative stress.[21] Pain stress directly mirrors the pain of patients after injuries, while oxidative stress is able to effectively reflect the antioxidant capacity of the whole body after injuries, mirroring the overall injured state of the body at a high level.[22] It has been reported that, for patients with fractures, the degree of body stress has a close correlation with the occurrence of complications, and in case of more severe pain stress, hemodynamics are affected to a certain extent, and the risk of cardiovascular diseases is increased, while more severe oxidative stress of patients suggests that the patients have an abnormal antioxidant capacity which, in turn, affects the formation of microvessels, hindering fracture healing, and thereby affecting the body recovery.[23-25] In this study, therefore, the effects of different therapies on body stress were analyzed, and the efficacy of a certain therapy was assessed according to the degree of stress. The results revealed that both pain stress and oxidative stress were at a high level in the three groups before treatment, and they increased after treatment, while oxidative stress injury of patient body was significantly relieved over time. This finding indicates that, after treatment, injuries of patients are obviously repaired, as evidenced by the alleviation of pain stress and oxidative stress. In this study, the patients treated via the posterolateral fibular approach had the best recovery, which was manifested as the most significant decreases in pain stress and oxidative stress in posterolateral approach group after the treatment. The above results indicate that, for patients with Grade 3/4 fractures, surgery can achieve faster recovery than conservative therapy, and fixation with posterolateral fibular approach can achieve the best efficacy.

Nonetheless, this study has some limitations. First, it is a single-center study with a relatively small sample size. Second, the influence of anesthetics on the evaluation of stress indexes was not excluded. Third, the patients were not standardized for comorbid diseases during the assessment of oxidative stress, and a healthy control group was not formed. Therefore, further multi-center studies with larger sample sizes are needed to confirm our findings.

In conclusion, for patients with supination-lateral rotation ankle fractures, fixation with posterolateral

fibular approach is more effective for expediting the recovery of ankle joints than conservative therapy and fixation with fibular approach, accompanied by a higher safety profile. However, further well-designed, large-scale prospective studies are warranted to draw a firm conclusion on this subject.

Ethics Committee Approval: The study protocol was approved by the Nanjing First Hospital Ethics Committee (date: 04.03.2020, no: 2019SHL-KY-03). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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