Original Article
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Fibular Fixation in Same-Level Distal Third Tibiofibular Fractures: Is Fibular Fracture Regarded as a Secondary Importance?

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Background: Although most studies focused on the alignment or union of the tibia in same-level distal third tibiofibular fractures, the outcome of a concomitant fibular fracture is generally regarded as being of secondary importance in the literature. This study aimed to assess the outcomes of fibular fractures in same-level distal third tibiofibular fractures.

Methods: In this retrospective study, we enrolled 111 patients with same-level distal third tibiofibular fractures treated at our institute between January 2016 and August 2020. Tibial fractures were stabilized with intramedullary nailing, and the cases were divided into two groups based on whether they additionally underwent fibular fixation (group 1, 57 cases) or not (group 2, 54 cases). Clinical and radiographic outcomes were used for the evaluation of tibial and fibular alignments, union of the tibia and fibula, number of interlocking screws in the distal tibial fragment, range of motion of the ankle joint, and complications.

Results: No statistically significant differences in the tibial union rate or mean tibial alignment were observed between the two groups on either the immediate postoperative or final radiographs. The fibular union rate in group 1 was significantly higher than that in group 2 (fibular nonunion, 0 vs. 15; $p < 0.001$). Statistically significant differences in fibular displacement were observed on immediate postoperative radiographs between patients with fibular union and those without it. At the final follow-up, the mean range of ankle motion and lower extremity functional scale scores did not differ between the two groups.

Conclusions: Regardless of whether fibular fixation was performed, the overall tibial alignment with intramedullary nailing was well restored and the union rate of the tibia was comparable in the two groups. Fibular nonunion is not uncommon in unfixed fibula fractures. Displacement of the fibula as seen on immediate postoperative radiographs was related to fibular nonunion.

Keywords: *Same-level distal third tibiofibular fracture, Fibular fixation, Tibial nailing, Malalignment, Nonunion*

Extra-articular distal tibial fractures, which are often caused by axial compressive, direct bending or low-energy torsional forces, are challenging to manage.[1,2] The surgical treatment of such fractures is influenced by proximity to the distal articular surface, the severity of comminution, combined fibular fractures, and concomitant soft-tissue injury.[3,4] Whether fibular fractures should be fixed in same-level distal third tibiofibular fractures, especially when the tibial fractures are treated with intramedullary

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nailing, remains controversial. Some clinicians advocate that fibular fixation combined with intramedullary nailing of the tibia decreases or improves malalignment of the tibia.[5,6] Conversely, others have stressed that stabilization of concomitant fibular fractures in same-level distal third tibiofibular fractures is not mandatory because it does not show any advantage regarding union or alignment of the distal third tibial fractures.[7-10] However, most studies regarding same-level distal third tibiofibular fractures focused on the alignment or union of the tibia. Although one prior study did evaluate the incidence of fibular nonunion while primarily assessing the outcomes of tibial fractures,[8] the concomitant fibular fractures are generally regarded as being of secondary importance in the literature.

This study was performed to assess the effect of fibular fixation on the overall outcome of fibular and tibial fractures in the same-level distal tibiofibular fractures treated with tibial intramedullary nailing. We hypothesized that this study would demonstrate no difference in the outcome of fibular fractures and that fibular fixation would not influence the outcome of tibial fractures in same-level distal tibiofibular fractures.

METHODS

The manuscript has been read and approved by all authors, and each author believes that the manuscript represents honest work. The Institutional Review Board of Wonju Severance Christian Hospital approved this study (No. CR322076). Informed consent was obtained from all individual participants included in the study.

Patient Selection and Demographics

Between January 2016 and August 2020, 122 patients consecutively underwent surgical treatment for same-level distal third diaphyseal tibiofibular fractures at five tertiary referral hospitals. Between January 2016 and July 2018, we performed open reduction and plate fixation for fibular fractures with simultaneous tibial intramedullary nailing in such patients (group 1). Fixation of fibular fractures was routinely performed until July 2018 because we thought fibular fixation was one of the factors affecting the alignment of distal 1/3 tibial fractures. However, there were different outcomes and opinions in many clinical studies regarding the role of fibular fixation;[7-10] therefore, we have left out the fibular fixation deliberately in the same level distal tibiofibular fractures since August 2018. Subsequently, the same-level distal third tibiofibular fractures were stabilized with tibial intramedullary nailing without fibular fixation (group 2). Seven patients in group 1 and four patients in group 2 were lost to follow-up.

The inclusion criteria were as follows: patients with skeletally mature fractures, acute distal third tibial fractures (type $42A_{(c)}$, $42B_{(c)}$, and $42C_{(c)}$ according to the AO Foundation/Orthopaedic Trauma Association [AO/OTA] classification), combined with fibular fractures at the same level (type $4F2A_{(c)}$ and $4F2B_{(c)}$ according to the AO/OTA classification); patients treated with tibial intramedullary nailing; and patients who were followed up for a minimum of 12 months. Patients with fibular fracture-associated ankle fractures (type 44A, 44B, and 44C according to the AO/OTA classification), distal tibial intra-articular fractures (type 43B and 43C), high fibular fractures ($4F2_{(a)}$ and $4F2_{(b)}$), fibular open fractures, and previous fibular fractures were excluded.

Surgical Techniques and Rehabilitation

All tibial fractures were treated with the intramedullary nail (Expert Tibia Nail; Synthes, Solothurn, Switzerland) with either the lateral parapatellar or transpatella tendon approach. Several techniques for reduction of the tibia were utilized according to the fracture configuration or existence of an open wound. For instance, a simple spiral fracture was reduced using pointed reduction forceps in a percutaneous manner, and the open fracture of the distal tibia was fixed with additional plating during the process of debridement or the surgery of soft-tissue coverage. In group 1, all fibular fractures were stabilized with open plating prior to tibial intramedullary nailing. We allowed and encouraged the patients to start range of motion exercises of the ankle immediately after the operation, and they were allowed weight-bearing as tolerated regardless of the fibular fixation.

Clinical and Radiographic Assessments

Patient demographics and characteristics, including age, sex, smoking status, alcohol consumption status, diabetes status, and body mass index, were reviewed. Clinical outcomes were assessed using the range of motion of the ankle joint and the lower extremity functional scale (LEFS) scores at the final follow-up.

The radiographs were assessed by two orthopedic surgeons blinded to all patient characteristics (HSS and JWL). The average of the measurements of the two observers was calculated and used for each parameter. The radiological parameters included time to union, presence of nonunion or malunion, and the number of screws in the distal tibial fragment. Axial alignments of the tibia and fibula in the anteroposterior and lateral views were viewed on both immediate postoperative and final radiographs (valgus +, varus –; anterior apex angulation +, posterior apex angulation –). Displacement of the fibula (mm) was measured on immediate postoperative radiographs in both groups. Bone union was assessed routinely at 2 weeks, 1 month, and every month thereafter until fracture healing. Nonunion was defined as the absence of evidence of the healing process in radiographs over 3 months or fractured bones that had not completely healed within 9 months (Food and Drug Administration guidelines). Disagreements regarding the interpretation of radiographs were resolved by consensus.

Statistical Analysis

The independent samples *t*-test or Mann-Whitney *U*-test was used to analyze continuous variables, and the chi-square test or Fisher's exact test was used for dichotomous variables to compare demographic data and clinical outcomes between the two groups. Statistical analyses were performed using IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA) with a 95% confidence interval.

RESULTS

Fifty-seven patients were surgically stabilized with open reduction and plate fixation for fibular fractures, and 54 patients were treated conservatively. In total, this cohort comprised 71 male and 40 female patients. The mean age was 48.6 ± 15.3 years (range, 16–86 years). The mean follow-up period was 13.7 ± 7.8 months (range, 12–41 months). The average time from injury to the operation was 3.6 ± 3.8 days (range, 1–20 days). The mechanism of trauma was slip-down injuries in 40 patients, fall injuries in 26 patients, motor vehicle accidents in 28 patients, and sports injuries in 17 patients. No statistically significant differences in demographic data between the two groups were observed (Table 1).

The mean time to union of the tibia did not significantly differ between the two groups (14.3 vs. 15.1 weeks, $p = 0.712$). The mean coronal tibial alignments on the immediate postoperative radiograph were 0.94° and 0.87° in groups 1 and 2, respectively ($p = 0.847$). The mean sagittal tibial alignment on the immediate postoperative radiographs were also comparable between the two groups (0.85° in group 1 vs. 0.64° in group 2, $p = 0.908$). Tibial alignment on final radiographs also did not significantly differ between the two groups. No statistically significant differences in tibial nonunion between the two groups were observed (6 vs. 7 cases) (Fig. 1).

When comparing the axial alignment of the fibula between the two groups, a statistically significant difference in the sagittal alignment of the fibula on immediate postoperative radiographs (anterior or posterior angulation in the lateral radiograph) was observed ($p = 0.007$). Group 2 patients demonstrated a statistically significant difference in fibular displacement as seen on the immediate postoperative radiograph (0.20 mm and 5.49 mm in groups 1 and 2, respectively, $p < 0.001$). The fibular nonunion rate in group 2 was significantly higher than that in group 1 (15 vs. 0, $p < 0.001$). The type of nonunion in fibular fracture was classified as 12 hypertrophic and 3 oligotrophic nonunion in the final radiographs. At the final

Table 1. Demographic Data of the Two Groups

Variable	Fixed fibula (group 1)	Unfixed fibula (group 2)	*p*-value
Number	57	54	-
Age (yr)	46.4 ± 16.2	50.9 ± 14.1	0.122
Sex (male : female)	36 : 21	35 : 19	0.856
Involved side (right : left)	34 : 23	30 : 24	0.663
Current smoker (%)	9 (15.8)	5 (9.3)	0.395
Heavy alcoholics (%)	2 (3.5)	1 (1.9)	1.000
Diabetic status (%)	3 (5.3)	5 (9.3)	0.482
Body mass index (kg/m^2)	25.7 ± 3.6	24.6 ± 3.7	0.362
Time from trauma to surgery (day)	3.2 ± 2.2	3.9 ± 5.2	0.607
Open fracture	17	18	0.838
Follow-up period (mo)	13.4 ± 8.6	14.0 ± 7.0	0.832
Trauma mechanism			0.841
Slip over	19	21	
Fall or rolling down	15	11	
Motor vehicle accident	15	13	
Sports injury	8	9	
Tibia AO/OTA classification			0.268
Simple 42A$_{(c)}$	22	28	
Wedge 42B$_{(c)}$	32	22	
Multi-fragmentary 42C$_{(c)}$	3	4	
Fibula fracture configuration			0.899
Simple 4F2A	39	35	
Wedge 4F2B	6	7	
Multi-fragmentary 4F2B	12	12	

Values are presented as mean ± standard deviation or number (%).
AO/OTA: AO Foundation/Orthopaedic Trauma Association.

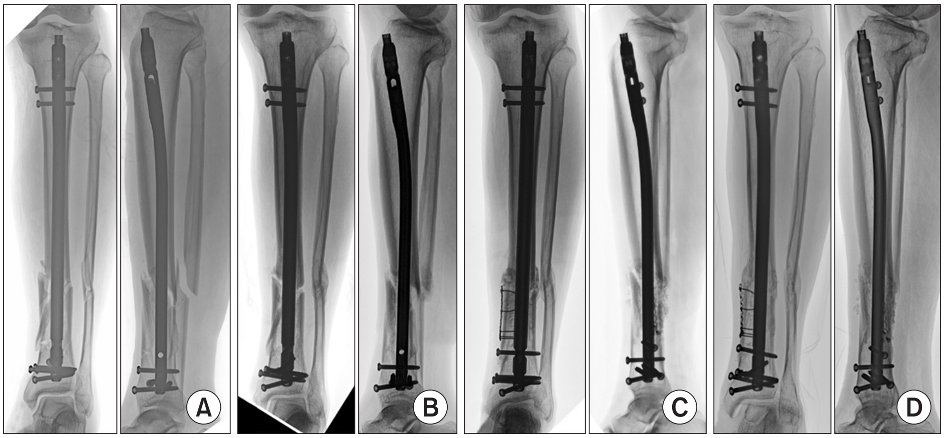

Fig. 1. (A) A 65-year-old male patient with a distal third tibiofibular fracture treated with tibial intramedullary nailing without fibular fixation. (B) Radiographs showing solid union of the fibula and nonunion of the tibia 5 months after the initial operation. (C) Autogenous bone grafting and additional fixation performed using an interlocking screw and a mini-fragment plate. (D) Final radiograph at 17 months showing solid bony union with an acceptable alignment of the tibia.

Table 2. Clinical and Radiographic Outcomes of the Two Groups

Variable	Fixed fibula (group 1)	Unfixed fibula (group 2)	*p*-value
IPOP tibial coronal alignment (°)	0.96 ± 2.2	0.87 ± 1.7	0.847
IPOP tibial sagittal alignment (°)	0.85 ± 1.6	0.64 ± 1.7	0.908
IPOP fibular coronal alignment (°)	0.29 ± 1.8	1.17 ± 3.9	0.267
IPOP fibular sagittal alignment (°)	0.21 ± 0.4	–1.43 ± 3.1	0.007*
IPOP fibular displacement (mm)	0.20 ± 0.3	5.49 ± 4.6	< 0.001*
Final tibial coronal alignment (°)	0.85 ± 2.3	0.90 ± 1.8	0.917
Final tibial sagittal alignment (°)	0.39 ± 1.7	–0.09 ± 1.8	0.176
Tibial nonunion	6 (10.5)	7 (13.0)	0.794
Fibular nonunion	0	15 (27.8)	< 0.001*
Number of distal interlocking screws	3.4 ± 3.1	3.6 ± 2.5	0.422
Use of blocking pin or screw	3	2	0.065
Use of supplementary plate	4	4	0.838
ROM of ankle joint	97.9 ± 5.0	95.7 ± 7.4	0.288
LEFS	74.3 ± 5.0	75.2 ± 3.5	0.434

Values are presented as mean ± standard deviation or number (%). Valgus or anterior apex angulation: +, varus or posterior apex angulation: –.
IPOP: immediate postoperative, ROM: range of motion, LEFS: lower extremity functional scale.
**p*-value < 0.05.

follow-up, the mean range of ankle motion and LEFS did not differ between the two groups (Table 2).

When the groups were divided based on fibular nonunion, only immediate postoperative fibular displacement showed a statistically significant difference (8.3 mm and 4.1 mm in fibular nonunion and union groups, respectively, $p = 0.01$). Four of the 15 patients with fibular nonunion complained of related symptoms, such as persistent pain while walking and tenderness, and 2 of them underwent revision surgery with fibular plating (Fig. 2) and eventually healed after fibular revision surgery (Tables 3 and 4).

DISCUSSION

In this study, the incidence of fibular nonunion was relatively high in the group of patients who did not undergo fibular fixation, and displacement of fibular fractures as seen on the immediate postoperative radiographs was significantly related to the fibular nonunion. No statistical differences in the clinical or radiological outcomes of tibial fractures re-

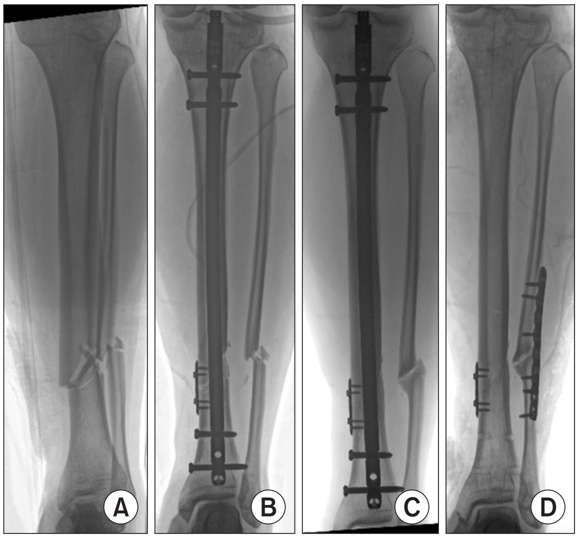

Fig. 2. (A, B) A 22-year-old male patient with a Gustilo-Anderson type II distal third tibial open fracture treated with tibial intramedullary nailing the same day as initial trauma. (C) He complained of pain in the lateral aspect of the injured leg while walking after 14 months of trauma. Radiographs showing solid union of the tibia with hypertrophic nonunion of the fibula. (D) The fibula was fixed with a 3.5-mm locking plate to provide stability to the previous fracture site, and the tibial nail was simultaneously removed.

Table 3. Comparison in Group 2 with or without Fibular Union

Variable	Fibular nonunion	Fibular union	*p*-value
Number	15	36	
IPOP fibular displacement (mm)	8.3 ± 5.8	4.1 ± 3.2	0.010*
IPOP fibular coronal alignment (°)	1.7 ± 3.7	–0.03 ± 4.1	0.114
IPOP fibular sagittal alignment (°)	–1.9 ± 2.9	–1.1 ± 3.2	0.411
Fibular fracture configuration			0.517
Simple 4F2A	6	14	
Wedge 4F2B	5	15	
Multi-fragmentary 4F2B	4	7	
Fibular nonunion symptom			-
No	11	-	
Yes	4	-	
Need revision surgery	2	-	

Values are presented as mean ± standard deviation. Valgus or anterior apex angulation: +, varus or posterior apex angulation: –.
IPOP: immediate postoperative.
**p*-value < 0.05.

gardless of whether the fibula was fixed were observed.

Although we hypothesized that fixing the same-level fractured fibula would not affect the clinical or radiological outcomes of the fractured tibia, the role of fibular fixation in extra-articular distal tibiofibular fractures is still controversial. Several biomechanical studies have previously shown that fibular plate fixation with tibial intramedullary nailing can reduce valgus malunion by increasing rotational stability.[11,12] Egol et al.[5] retrospectively reviewed 72 fracture cases and revealed that fibular fixation helps in preventing late (12 weeks or later) malalignments. In this study, however, we observed that fibular fixation prevents neither late tibial malalignment (after more than a year of the mean follow-up period) nor immediate tibial malalignment, and this result was consistent with our hypothesis. These conflicting results may be due to several reasons. The development of tibial nail design allows more locking screws to be inserted into the distal fragment,[13] and the introduction of advanced techniques, such as blocking (poller) screws[14] and tibial supplementary plating, has made it easier to correct the instability of the distal fragment due to the difference between the distal tibial medulla and nail diameter. Relatively recent studies have often supported our view that fibular fixation does not affect the outcome of tibial fracture healing, such as union rate or malunion.[8,9,15]

Most previous studies investigating same-level distal third tibiofibular fractures have focused only on the outcome of tibial fractures, and little published evidence of the nonunion rate of concomitant fibular fractures in same-level distal third tibiofibular fractures is available. In the current study, we focused on the outcome of fibular fractures, and the results revealed a significantly higher fibular nonunion rate in the group of patients who did not undergo fibular fixation (27.8%, 15 of 54 patients). Nonunion of the fibula is considered relatively less important than that of other bones; therefore, little data on this condition is available, and most information is related to the component of malleolar fractures of the ankle. In the present study, the fibular nonunion rate in the group of patients who did not undergo fibular fixation was considerably higher (27.8%); however, the true evidence of the incidence of fibular shaft nonunion was inadequate to compare our findings. The fractures in the distal part of the lower leg are considered to have a higher nonunion risk than those in other parts because of the low blood supply and increased micromotion due to the relatively low soft-tissue coverage compared to the proximal and middle parts. Although to date no studies comparing the nonunion rate according to the fibular fracture level have

Table 4. Multivariable ORs of Risk Factors for the Prediction of Fibular Nonunion

Variable	B	OR		*p*-value
		Estimate OR	95% CI	
IPOP fibular displacement (mm)	–0.863	3.422	1.70 to 6.56	0.012*
IPOP fibular coronal alignment (°)	0.169	1.184	–4.02 to 17.2	0.156
IPOP fibular sagittal alignment (°)	1.102	3.010	–2.55 to 1.06	0.115
Fibular fracture configuration	–17.460	0.000	0.28 to 1.75	0.999
Tibia union	–0.157	0.855	0.35 to 4.29	0.956

OR: odds ratio, CI: confidence interval, IPOP: immediate postoperative.
**p*-value < 0.05.

been conducted, a previous review article by Bhadra et al.[16] reported that the incidence of nonunion of the distal fibular fractures accounts for 86.5% of the total incidence of fibular nonunion (proximal: middle: distal = 1 : 11 : 90). Therefore, considering that concomitant tibiofibular fractures are caused by relatively high-energy trauma and that the distal fibular fractures have a higher nonunion risk than those at other levels, we believe that the high nonunion rate of 27.8% in our study is possible.

Fracture nonunion can occur due to various causes arising from host, biological, and mechanical factors, and the same applies to fibular nonunion. However, the fibula differs from other bones in that alignment or rotation with the adjacent tibia must be considered. In the past, nonunion of the fibula was considered an indicator of fixation instability of the fractured tibia.[17] However, it is reasonable to assume that fibular nonunion will not act as a tibial nonunion indicator at this time, just as the bone union of the fibula was not related to the tibial clinical or radiological outcome in this study. In other words, the fibula itself must be the cause of fibular nonunion. In the current study, immediate postoperative displacement was the only factor affecting fibular nonunion, with the mean displacement in the nonunion group being 5.49 mm, as seen on immediate postoperative radiographs. This result was also comparable to that of a previous study on fibular nonunion in patients with distraction osteogenesis of the tibia.[18] The length of the fibular distraction, which may be substituted as the displacement of the fibula in this study, is a significant risk factor for fibular nonunion that occurs mainly in the distal third of the fibula.[18] The diameter of the fibula is about 10 mm, and the nonunion rate increases when a displacement measuring 1/3 to 1/2 of the fibula diameter occurs.[19,20] Therefore, we suggest that the displacement of the fibula might be the determining factor for the stabilization of the fibular fracture during the operation.

This study has several limitations. First, because of the patients with short-term follow-up and retrospective case series study design, it was not amenable to clarify the effect of fibular fixation. Second, the patients were enrolled in different time periods; however, we applied the same indication and standardized the protocol to reduce bias between the groups. Third, since this study was a multicenter study, there might be a surgeon-related bias. Despite these limitations, to the best of our knowledge, this study is one of the largest comparative studies focusing on the outcomes of concomitant fibular fractures in same-level distal third tibiofibular fractures.

In conclusion, we found that the overall tibial alignment with intramedullary nailing was well restored and the union rate of the tibia was comparable regardless of whether fibular fixation was performed. However, an unfixed fibula was significantly associated with fibular nonunion. We recommend fibular fixation when significant displacement of the fibular fracture is observed intraoperatively, considering that displacement of the fibular fracture is related to nonunion.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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