

Locking plate versus retrograde intramedullary nail fixation for tibiotalocalcaneal arthrodesis

A retrospective analysis

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ABSTRACT

Background: Tibiotalocalcaneal arthrodesis (TTCA) surgery is indicated for the end-stage disease of the tibiotalar and subtalar joints. Although different fixation technique of TTCA has been proposed to achieve high fusion rate and low complication rate, there is still no consensus upon this point. The purpose of this study is to compare the clinical efficacy of retrograde intramedullary nail fixation (RINF) and locking plate fixation (LPF) for TTCA.

Materials and Methods: Fifty four patients who underwent TTCA through the lateral approach with lateral fibular osteotomy using RINF (32 patients, 18 male/14 female, mean age: 48) or LPF (22 patients, 12 male/10 female, mean age: 51) between January 2007 and January 2010 were retrospectively analyzed. Demographic and clinical characteristics, surgery (operation time, blood loss) outcomes (postoperative fusion rates, visual analog scale and foot and ankle surgery score and complications) were compared.

Results: The LPF group had a shorter operation time (72.3 ± 9.2 vs. 102.8 ± 11.1 min, $P < 0.001$), less blood loss (75.9 ± 20.2 vs. 140.0 ± 23.8 ml, $P < 0.001$) and less intraoperative fluoroscopy sessions (3.6 ± 0.9 vs. 8.4 ± 1.3 , $P < 0.001$) than the RINF group. Patients were followed up for 12–24 months (mean of 16.2 months). Both groups had similar postoperative fusion rates (90.6% and 95.4%) and the LPF group showed a nonsignificant lower complication rate (18.2% vs. 28.1% respectively). Patients at higher risk on nonunion due to rheumatoid diseases may have a lower nonunion rate with LPF than RINF (one out of eight vs. three out of nine, $P < 0.001$).

Conclusions: The LPF for TTCA was simpler to perform compared with RINF, but with similar postoperative outcomes and complication rates.

Key words: Locking plate fixation, retrograde intramedullary nail, subtalar arthritis, tibiotalar arthrodesis, tibiotalocalcaneal arthrodesis

MeSH terms: Ankle, bone plates, intramedullary, arthrodesis, nailing

INTRODUCTION

Tibiotalar and subtalar joints are critical components of the ankle back foot complex to maintain a normal activity and flexibility of the ankle area and are essential for weight bearing and walking. Secondary lesions of the tibiotalar and subtalar joints caused by injury,

developmental disorders or chronic tendon dysfunction at ankle joint or hind foot can cause severe pain, deformity and walking dysfunction. For those patients who do not obtain satisfactory efficacy from conservative treatment, surgical treatment might relieve pain and restore function. Tibiotalar joint replacement plus fusion of subtalar joint was previously proposed.¹ However, this surgery is complicated and has uncertain long term outcomes. Tibiotalocalcaneal arthrodesis (TTCA) showed favorable outcomes and restored normal daily life function and is still the gold standard surgery for end stage disease of the tibiotalar and subtalar joints.² TTCA was first introduced by Lexer in 1906.^{3,4} With the development of new implanted devices and improvement of surgical techniques, the fusion rate of TTCA gradually increased and the complication rate decreased.^{5,6} Surgical fixation materials used in TTCA include screws, external fixator and angle plate. However, TTCA may be achieved through several fixation methods: Pressure screw fixation, angle plate fixation, retrograde intramedullary nail fixation (RINF) and locking plate fixation (LPF).

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Retrograde intramedullary nail fixation has the advantages of simple and easy operation and practical application. It is an effective fixation method with fusion rates of 71–95%.^{7,8} However, this method requires the reaming, which may increase the possibility of systemic inflammation, pulmonary embolism and infection. In recent years, the appearance of the LPF method provided great support for traumatic orthopedic treatment. LPF has significant advantages for the treatment of severe comminuted fractures, periarticular fractures and osteoporotic fractures, compared with traditional plate fixation.^{9,10} For peri and intraarticular fractures, locking plates and screws with angle stability design have the advantage of significantly enhancing the structural stability of plates and screws, greatly increasing the resistance to shear and pull out force. Even for severe osteoporotic fractures, LPF has very high fixation capacity. Locking plates work as internal fixator and do not have direct contact with the bone. Therefore, periosteal blood supply is not hampered due to direct pressure of the plate over the bone, as was observed with dynamic compression plates.¹¹⁻¹⁴

Despite the increased use of LPF, which is relative simpler and showed reliable fixation strength for TTCA,¹¹⁻¹⁴ it is still controversial which approach is better for TTCA: LPF or RINF? Therefore, we retrospectively analyzed the clinical outcomes of 54 patients operated for TTCA by RINF or LPF. We observed that LPF had some relative advantages (fewer postoperative complications and simpler operation) over RINF.

MATERIALS AND METHODS

We retrospectively reviewed the records of 71 patients who underwent TTCA by RINF or LPF in our Hospital between January 2007 and January 2010. All patients had a diagnosis of tibiotalar and subtalar joints lesions by ankle and foot weight bearing X-ray, computed tomography, and/or magnetic resonance imaging. The eligibility criteria included severe tibiotalar joint lesions combined with subtalar joint lesions and failure to respond to a fair trial of conservative therapy. Exclusion criteria included active infectious disease, diabetes mellitus, severe congenital bone defects or revision surgery. 54 patients were included in the final analysis. All 54 patients had preoperative visual analog scale (VAS) and American Orthopaedics Foot and Ankle Society (AOFAS) ankle and hindfoot assessment of injured limbs. This study was approved by the Ethics Committee of the Hospital affiliated to the University.

Patients with severe rheumatoid diseases (high inflammatory state) were considered at higher risk of nonunion, while other patients (osteoporosis, bone loss or previous surgery)

were considered at lower risk of nonunion. Osteoporosis was diagnosed based on the results of dual energy X-ray absorptiometry and according to the guidelines from the World Health Organization.¹⁵

Operative procedure

All surgeries were performed by three experienced ankle and foot surgeons (CZ, ZS, GM). Patients received general anesthesia or spinal anesthesia and were placed in the lateral position. A tourniquet was used and the ipsilateral iliac region was prepared for iliac bone graft. The fibula was exposed by lateral approach, from tip to 3 cm proximal to tibiofibular joint. An oblique fibular osteotomy was done. The inferior tibiofibular joint was exposed and the external lateral distal tibia was exposed. The tibiotalar and subtalar joints were exposed under the assistance of a tibial distraction device. Intraarticular osteophyte was cleaned and cartilage was removed using shovels. A 2 mm Kirschner wire was used to puncture holes evenly on the articular surface. The distal end of the fibula segment was cut in the coronal plane. The inner cancellous bone was removed completely and the tibiotalar and subtalar joint grafts were trimmed to cancellous bone particles. If the graft was not satisfying, ipsilateral iliac cancellous bone was taken for grafting. Tibiototalcalcaneal joint was temporarily fixed with Kirschner wires after grafting. C-arm fluoroscopy was used to confirm limb alignment and a full amount of bone graft. After thorough discussion and communication between the surgeon and the patient, RINF (Versa Nail, Depuy, USA) or proximal humeral LPF (PHILOS, Synthesis, Swiss) was performed.

(a) Retrograde intramedullary nail fixation method.

A guidance needle was passed percutaneously under image intensifier at the junction of the long axis line through the second toe to foot bottom and a line at about one-third distal to the heel. Intramedullary nails of appropriate length were placed retrogradely after the guidance needle was placed at the right position under fluoroscopy. Two screws were placed at the proximal tibia level, one screw in the distal calcaneus bone and one screw at the talus bone [Figure 1].

(b) Humeral proximal end locking plate fixation method

The LPF method is shown in Figure 2. First, steel plate was molded based on lateral anatomy of the tibiotalar and subtalar joints. After the plate was adjusted in a satisfactory position under C-arm fluoroscopy, the plate and calcaneus were fixed with two locking screws. Then, normal cortical bone screws were used to fix through the sliding pressure hole at the tibial stem part. Usually, three to four screws are needed for calcaneus and tibia fixation and two nails are



Figure 1: (a) X-ray of ankle joint with leg anteroposterior and lateral views showing subtalar arthritis (b) immediate postoperative x-rays showing retrograde inter locking nail used to fuse tibiotalar calcaneal joint (c) followup x-rays at 6 months post surgery showing good union

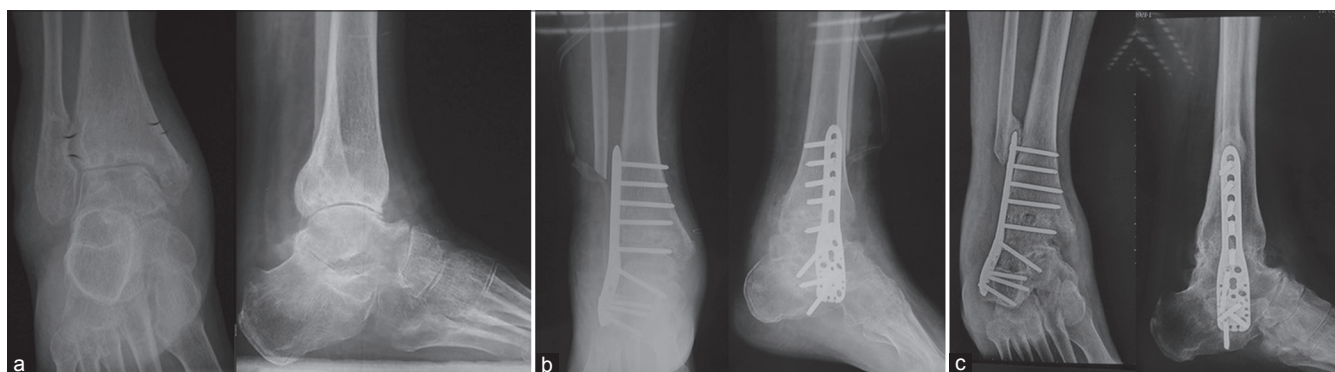


Figure 2: (a) X-ray of ankle joint with leg anteroposterior and lateral views showing subtalar arthritis (b) postoperative x-rays anteroposterior and lateral views of locked plate fixation for tibiotalar calcaneal fusion (c) followup x-rays at 6 months after surgery of locked plate fixation group of tibiotalar calcaneal fusion showing good union

needed for talus fixation. After cleaning, a drainage tube was placed and incisions were sutured in layers.

Intraoperative blood loss was estimated in each patient by a gravimetric method.¹⁶ Elastic bandages and ice bag were used after operation. Conventional intravenous antibiotics were administered for 48 h. The patients gradually began weight bearing training after 4 weeks. Assessments of VAS and AOFAS score were performed at every 4 weeks [Figure 2].

Statistical analysis

Continuous variables are presented as mean \pm standard deviation and the Student's *t*-test was used to compare the groups. Categorical variables are presented as proportions and were analyzed using the Chi-square test. All statistical analyses were performed using SPSS 11.0 (SPSS Inc., Chicago, IL, USA). $P < 0.05$ indicated statistically significant differences.

RESULTS

Fifty four patients with severe tibiotalar joint lesion combined with subtalar joint lesion, which failed to respond to a fair trial of conservative therapy, underwent TTCA surgery with

RINF ($n = 32$, 18 males [56.3%] and 14 females [43.7%]) or LPF ($n = 22$, 12 males [54.6%] and 10 females [45.4%]). There was no significant difference in gender ($P = 1.00$), mean age at surgery (48 ± 11 vs. 51 ± 12 years, $P = 0.34$) and laterality of lesion ($P = 0.58$) between the RINF and LPF groups. The main cause of disease was traumatic arthritis (46.9% and 45.4% respectively), followed by osteoarthritis (28.1% and 27.3% respectively) and rheumatoid arthritis (12.5% and 13.6%). Other reasons included Charcot joint disease, talus necrosis or ankle joint tuberculosis. Among all subjects 62.5% and 63.6% patients in the two groups had a previous history of surgery, 56.2% and 54.6% patients suffered from osteoporosis and 12.5% and 13.6% patients suffered from bone mass loss respectively. In the two groups, 28.1% ($n = 9$) and 36.4% ($n = 8$) patients, respectively were at higher risk for nonunion because they were suffering from severe rheumatoid disease and were, therefore, suspected of having a higher inflammatory state. There was no significant difference for disease causes or surgical co-morbidities between the two groups (all $P > 0.05$) [Table 1].

The mean followup time was 16.2 months (range 12–24 months). RINF needed longer operation time compared with LPF (102.8 ± 11.1 vs. 72.3 ± 9.2 min,

$P \leq 0.001$). The average blood loss in RINF patients was 64 ml more than that of LPF patients (140.0 ± 23.8 vs. 75.9 ± 20.2 ml, $P \leq 0.001$). RINF patients also needed more sessions of the perspective examination by fluoroscopy (8.4 ± 1.3 vs. 3.6 ± 0.9 , $P \leq 0.001$). However, the postoperative fusion time of RINF patients was significantly shorter than that of LPF patients (14.2 ± 2.4 vs. 18.6 ± 3.8 weeks, $P \leq 0.001$). The final complete fusion rates in RINF and LPF groups

were 90.6% (29/32) and 95.4% (21/22), respectively. For those patients at higher risk for nonunion, the nonunion rate in the RINF group was 33% (3/9), while it was 12.5% (1/8) in the LPF group ($P < 0.05$), but the subgroups were too small to reach any firm conclusions. Except for postoperative fusion time, LPF patients showed significant advantages in all other aspects over RINF patients. The average VAS scores in both RINF and LPF groups were decreased after surgery, from 6.2 ± 0.9 to 1.5 ± 0.8 and from 6.6 ± 1.3 to 1.4 ± 0.8 , respectively. The average AOFAS scores in both groups were increased after surgery, from 36.4 ± 8.1 to 73.6 ± 6.4 and from 38.2 ± 9.7 to 76.3 ± 6.2 , respectively. However, there was no significant difference for preoperative or postoperative VAS and AOFAS between the two groups ($P > 0.05$).

Table 1: Patient's demographic and disease characteristics

Technique and P value	RINF (n=32) (%)	LPF (n=22) (%)	P
Patient information			
Gender			
Male	18 (56.3)	12 (54.6)	1.0000
Female	14 (43.7)	10 (45.4)	
Age (mean±SD) (years)	48±11	51±12	0.3365
Lesion side			
Left	18 (56.3)	10 (45.4)	0.5804
Right	14 (43.7)	12 (54.6)	
Cause of lesion			
Traumatic arthritis	15 (46.9)	10 (45.4)	0.9756
Osteoarthritis	9 (28.1)	6 (27.3)	
Rheumatoid arthritis	4 (12.5)	3 (13.6)	
Charcot arthritis	2 (6.2)	1 (4.6)	
Talar necrosis	2 (6.2)	1 (4.6)	
Ankle joint tuberculosis	0 (0)	1 (4.6)	
Surgical comorbidities			
History of surgery	20 (62.5)	14 (63.6)	0.9937
Osteoporosis	18 (56.2)	12 (54.6)	
Obesity	10 (31.2)	6 (27.3)	
Long history of smoking	8 (25)	4 (18.2)	
Bone mass loss	4 (12.5)	3 (13.6)	
High nonunion risk (severe rheumatoid disease)	9 (28.1)	8 (36.4)	0.5219

SD=Standard deviation, RINF=Retrograde intramedullary nail fixation, LPF=Locking plate fixation

Superficial wound infections (three RINF cases and one LPF case) were managed by dressing and intravenous antibiotics. Bone nonunions (three RINF cases and one LPF case) were successfully treated with revision surgery in one patient in the RINF group and one patient in the LPF group; the other two patients in the RINF group refused revision surgery. Wound skin flap necrosis was observed in one case in the RINF group and two cases in the LPF group and healed after debridement and re-suture. One case in the RINF group suffered from transient lower oxygen saturation and decreased blood pressure during reaming; he recovered with medical treatment. Another case in the RINF group suffered from lacunar infarction 2 days after surgery, but without significant sequelae after medical treatment. The two groups of patients had similar complication rates ($P = 0.52$) [Table 2].

Table 2: Outcomes and complications

Technique and P value	mean±SD (range)		P
	RINF (n=32)	LPF (n=22)	
Outcomes and complications			
Operation time (min)	102.8±11.1 (80-130)	72.3±9.2 (60-90)	<0.001
Blood loss (ml)	140±23.8 (80-200)	75.9±20.2 (50-120)	<0.001
Intraoperative perspective examination	8.4±1.3 (7-12)	3.6±0.9 (2-5)	<0.001
Postoperative fusion time (week)	14.2±2.4 (12-20)	18.6±3.8 (12-28)	<0.001
VAS score			
Preoperative	6.2±0.9 (5-8)	6.6±1.3 (5-9)	0.1816
Postoperative	1.5±0.8 (0-3)	1.4±0.8 (0-3)	0.6834
AOFAS score			
Preoperative	36.4±8.1 (23-52)	38.2±9.7 (28-60)	0.4579
Postoperative	73.6±6.4 (60-84)	76.4±6.2 (65-85)	0.1206
Postoperative total fusion rate %	90.60	95.40	0.638
Nonunion rate in high nonunion risk group, n (%)	3/9 (33)	1/8 (12.5)	0.603
Surgical complications (total) (n (%))	9 (28.1)	4 (18.2)	0.523
Infection	3 (9.4)	1 (4.5)	0.638
Bone union	3 (9.4)	1 (4.5)	0.638
Wound skin necrosis	1 (3.1)	2 (9.1)	0.563
Cardiopulmonary cerebrovascular disease	2 (6.3)	0 (0)	0.508

VAS=Visual analog scale, AOFAS=U.S. foot and ankle surgery score, RINF=Retrograde intramedullary nail fixation, LPF=Locking plate fixation, SD=Standard deviation

DISCUSSION

The present study retrospectively analyzed the outcomes and complications of 54 patients with severe tibiotalar joint lesion combined with subtalar joint lesion, which failed to respond to a fair trial of conservative therapy and who received TTCA surgery with RINF or LPF. Compared with LPF, RINF surgery required longer operative time and more intraoperative fluoroscopy examinations and induced more blood loss, although it had less postoperative fusion time than LPF. The complication rates in the RINF group were slightly higher than that of LPF group. These results suggest that LPF may be a better option for TTCA treatment than RINF.

TTCA surgery is usually indicated for the treatment of severe tibiotalar joint lesion combined with subtalar joint lesion, which is not satisfactory due to its low fusion rate compared with normal ankle joint arthrodesis. That is because the lesions treated using TTCA are generally more severe and with a higher incidence of inflammatory joint disease and severe osteoporosis. TTCA is a difficult surgery requiring stronger fixation methods to increase the fusion rate.¹⁷ RINF and LPF were considered as potentially good methods for TTCA. Tavakkolizadeh *et al.*¹⁸ used RINF to treat 26 patients with tibiotalar joint and subtalar joint lesions, and obtained good postoperative AOFAS scores of 66. Kamath *et al.*¹⁹ achieved 74.6 postoperative AOFAS for their patients with rheumatoid arthritis, which was comparable to the scores we obtained in the present study. Mendicino *et al.*³ reported that 25% of patients who received TTCA using RINF had severe complications such as osteomyelitis, nonunion, and pulmonary embolism and that 55% of patients had complications such as wound skin necrosis and superficial skin infection. The mechanical stability of integration area of RINF is relatively limited, which might affect fusion. Bennett *et al.*²⁰ found that RINF had limited antirotation stability and needed auxiliary straddle nail for fixation. In addition, the RINF method is only suitable for patients with co-existing degeneration the of tibiotalar and subtalar joints. In recent years, RINF was used for patients with ankle arthritis combined with subtalar arthritis and achieved good results.

Ahmad *et al.*²¹ reported a group of 18 patients treated for TTCA with LPF at proximal humerus and 17 out of 18 patients (94.4%) achieved fusion with no obvious complications. Several biomechanical studies^{22,23} confirmed that compared with RINF, using cannulated compression screw nail and angle plate methods, LPF had the best biomechanical fusion strength for TTCA surgery, especially for patients with osteoporosis, as well as in other population of patients.¹¹⁻¹⁴ We also treated

patients for TTCA with LPF at proximal humerus. We used a sufficient number of locking screws to fix the tibia-talus and calcaneus, which should result in a stronger fixation and improved compression on fused bone to provide excellent stability for TTCA and increased fuse rate, as previously shown.¹¹⁻¹⁴ However, the plates were not designed specifically for TTCA. The position and orientation of the screws for fixing tibia, talus, and calcaneus were not optimal in some patients. In these cases, light shaping had to be performed to fit the specific regional anatomic structure of these patients. However, the shaping was very light, and did not compromise the solidity of the plate.²⁴

All patients in the present study underwent osteotomy fusion through the lateral ankle approach path. This approach could directly expose the distal tibia-talus-lateral side of the calcaneus-tibiotalar and subtalar joints. The osteotomized distal fibula was used as cancellous bone graft. A previous analysis considers that this technique is mature.²⁵ However, a previous study retained as much cancellous bone mass than possible,²⁶ while we removed a large part of the cancellous bone. Nevertheless, it did not seem to negatively affect our outcomes, but a comparative study should be performed to reach any firm conclusion on this point. Indeed, this approach could eliminate effects of surgical approaches and surgical techniques on clinical efficacy. Some studies reported that RINF achieved better fusion rates and less surgeon-associated complications.^{5,6} We found that the LPF method needed less operation time, had less intraoperative blood loss and required less surgical perspective examinations. Previous studies showed that shorter surgical time and nonreaming operation also reduced the incidence of postoperative wound infection.^{27,28} Although both groups had good joint fusion rates, results may suggest that LPF resulted in a lower nonunion rate in patients with higher nonunion risk compared with RINF. This might be due to higher fixation strength, which in turn increased fusion rate using LPF,¹¹⁻¹⁴ but studies in larger samples are required.

The limitations of this study are that it was a retrospective analysis. There was no randomization. The average followup time was 16 months, which was relative short. Finally, the sample size was relatively small, but still larger than some previous studies ($n = 18-27$).^{18,19,21} In addition, we tried to perform a subgroup analysis in patients with a higher inflammatory state, but it resulted in small subgroups. Longer followup and larger sample size are required to further compare outcomes and possible complications of the two methods. Nevertheless, the results of the present study could serve as a basis for larger clinical trials.

In summary, the LPF for TTCA was simpler to perform compared with RINF, but with similar postoperative outcomes and complications.

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