Original Article Clinics in Orthopedic Surgery 2024;16:636-640 • https://doi.org/10.4055/cios24003

Midterm Results after Tibiotalar or Tibiotalocalcaneal Fusion Using an Ilizarov External Fixator

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Background: Ankle fusion is considered a treatment of choice for end-stage ankle arthritis when a total ankle replacement procedure is not indicated. However, the potential risk of secondary arthritis in the adjacent joint after ankle fusion raises arguments on whether preserving the adjacent joint during an isolated tibiotalar (TT) fusion brings about any future benefits with regard to pain and gait discomfort. In this study, we intended to present midterm results following TT or tibiotalocalcaneal (TTC) fusion using an Ilizarov external fixator and to investigate whether spontaneous fusion occurred in the subtalar or midtarsal joint.

Methods: This is a retrospective observational study. Medical records of patients who underwent TT or TTC fusion using an Ilizarov external fixator for substantial bone defects around the ankle joint between 1994 and 2018 were manually searched. Forty-one patients were included and the status of the joints adjacent to the fusion site was evaluated in radiographic examinations.

Results: Of the 34 patients who underwent TT fusion, 30 patients (88.3%) had a spontaneous fusion in the adjacent joints. Specifically, 11 patients (29.4%) had subtalar joint fusion and 19 patients (55.9%) had both midtarsal joint and subtalar joint fusion. In TTC fusion, the midtarsal joint was spontaneously fused in all 7 patients.

Conclusions: In this study, we observed spontaneous adjacent joint fusion following TT or TTC fusion using an Ilizarov external fixator for substantial bone defects around the ankle joint. Although a careful approach should be made since patients treated in this study may not represent typical candidates that need primary joint-sacrificing procedures, we believe that this study may draw attention from surgeons concerned about the fate of the adjacent joint status after TT or TTC fusion.

Keywords: *Ankle, Arthritis, Arthrodesis*

Ankle fusion is considered a treatment of choice for end-stage ankle arthritis when a total ankle replacement (TAR) procedure is contraindicated.[1] It is known to be effective in relieving pain by eliminating joint motion and providing stability.[2] In this context, a recent meta-analysis reported that ankle fusion and TAR produce similar clinical outcomes.[3]

However, ankle fusion involves a potential risk of postoperative nonunion, malunion, limb shortening, and

Received January 3, 2024; Revised January 25, 2024; Accepted February 12, 2024
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adjacent joint arthritis.[4] Among these, the possible risk of secondary arthritis on the adjacent joint raises arguments on whether preserving the adjacent joint during an isolated tibiotalar (TT) fusion brings about any future benefits with regard to pain and gait discomfort.[5] For this reason, some surgeons suggest primary tibiotalocalcaneal (TTC) fusion over TT fusion, although there is no proven correlation between radiographic changes in the subtalar or midtarsal joint and clinical necessity for a secondary procedure.[6,7]

Among many fusion options, an Ilizarov external fixator method is indicated in specific cases when there is a substantial bone defect around the ankle joint, which is trauma-, infection-, or tumor resection-related.[8] This method can provide stable fixation, deformity correction, bone transport, and fusion site compression. Interestingly, authors found that adjacent joints spontaneously fused after TT or TTC fusion using an Ilizarov external fixator (Figs. 1 and 2). In this study, we intended to present midterm results following TT or TTC fusion using an Ilizarov external fixator and to investigate whether spontaneous fusion occurred in the subtalar or midtarsal joint.

METHODS

This retrospective observational study was performed with approval of Ethics and Scientific Committee of Ernakulam Medical Centre, and all participants signed approved informed consent forms.

Medical records of patients who underwent TT or TTC fusion using an Ilizarov external fixator for substantial bone defects around the ankle joint between 1994 and 2018 were manually searched. The cause of the bone defect was either posttraumatic or osteomyelitis-related. Exclusion criteria included patients with previous fusion procedures for any other joints of the ipsilateral foot, poliomyelitis, congenital deformity, and a Charcot joint. Those who were lost to follow up were also excluded. Ultimately, 41 patients who met the criteria were included in this study.

As for a fusion procedure, the tibia, talus, or calcaneus was denuded of cartilage and meticulous debridement of the necrotic and infected bone and soft tissue was carried out. To fill the bone defect, a tibial corticotomy was performed simultaneously. If soft-tissue coverage was not possible due to extensive bone or joint exposure, a free vascularized latissimus dorsi or gracilis flap was used prior to an attempted fusion. Then, an all-wire or hybrid Ilizarov frame (S.H Pitkar Orthotools) was used in all patients. The standard frame configuration consisted of 1 or 2 tibial rings proximal to the corticotomy site, 1 or 2 rings at the corticotomy site, 2 rings in the tibia shaft, and a half ring with 2 calcaneal wires and 2 talar drop wires in the hindfoot. On the forefoot, 2 wires were fixed to connection plates, which were attached to a hindfoot half ring.

After the operation, weight-bearing on the operated limb was allowed as tolerated, using crutches. Progressive compression of the fusion site was initiated at the rate of 1 mm/day. Distraction at the corticotomy site followed at 7 to 10 days after operation and continued until the bone ends docked or limb-length discrepancy became normal-

Fig. 1. (A) A 44-year-old man presented with an open distal tibiofibular fracture and significant bone loss. (B) A tibiotalar fusion was performed using an Ilizarov external fixator. (C) Spontaneous subtalar joint fusion was achieved at 1 year after ring removal (arrows).

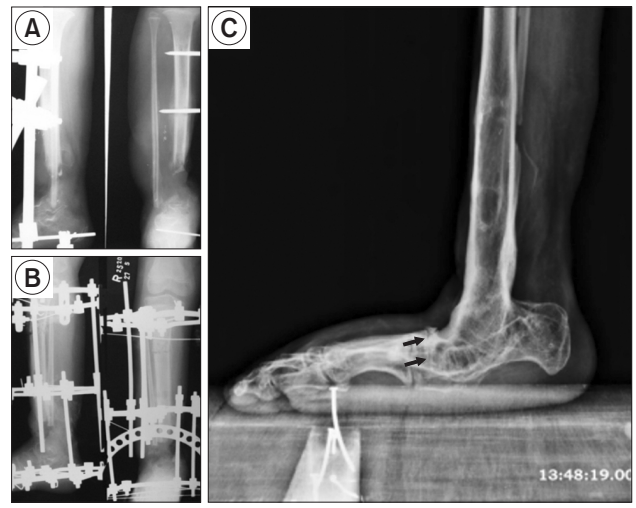

Fig. 2. (A) A 50-year-old man with infection after an open distal tibiofibular fracture. (B) A tibiotalocalcaneal fusion was performed using an Ilizarov external fixator. (C) Spontaneous midtarsal joint fusion was achieved at 17 years after ring removal (arrows).

ized. The frame was removed when the ankle fusion united, the regenerated bone matured, and a patellar tendon bearing cast was applied in all patients.

At the last follow-up, the patients underwent a radiographic examination as follows: (1) bilateral standing anteroposterior and oblique radiographs of the foot, (2) bilateral standing anteroposterior and mortise radiographs of the ankle, and (3) bilateral standing lateral radiographs of the foot and ankle. Using these radiographs, 2 reviewers evaluated the status of the joints adjacent to the fusion site and verified the alignment of the foot and ankle. These were undertaken simultaneously, and consensus was obtained for each case. Complications that occurred following the surgery were analyzed: infection, deformities, and delayed union.

Table 1. Patient Demographics

Variable	Total (n = 41)
Age (yr)	35.66 ± 14.24 (7–68)
Sex	
Female	4 (9.8)
Male	37 (90.2)
Type of fusion	
TT	34
TTC	7
Days in ring fixator	390.98 ± 191.51 (93–882)
Last follow-up since ring removal (yr)	5.71 ± 5.40 (0.5–20)
Fusion site union	
Yes	41 (100)
No	0

Values are presented as mean ± standard deviation (range) or number (%).
TT: tibiotalar, TTC: tibiotalocalcaneal.

Table 2. Adjacent Joint Fusion

	Total	MT only	ST only	Both MT and ST	No fusion
TT	34	0	11 (29.4)	19 (55.9)	4 (11.7)
TTC	7	7 (100)	-	-	0

Values are presented as number (%).
MT: midtarsal, ST: subtalar, TT: tibiotalar, TTC: tibiotalocalcaneal.

RESULTS

The mean age of the patients was 35.66 years (range, 7–68 years). There were 37 men and 4 women. In 5 patients, there were associated fractures of the ipsilateral tibia. TT fusion was performed in 34 patients and TTC fusion in 7. The mean duration of follow-up after ring removal was 5.71 years (range, 0.5–20 years). The mean duration of the ring fixator use was 390.98 days (range, 93–882 days). Fusion site union was achieved in all patients (Table 1).

Of the 34 patients who underwent TT fusion, spontaneous fusion of the adjacent joints was achieved in 30 patients (88.3%). Specifically, 11 patients (29.4%) had subtalar joint fusion and 19 patients (55.9%) had both midtarsal joint and subtalar joint fusion. There was no patient who showed midtarsal joint fusion alone. In TTC fusion, midtarsal joint was spontaneously fused in all 7 patients (Table 2).

In terms of postoperative complications, infection occurred in 8 patients. A total of 23 patients failed to achieve plantigrade foot and showed some form of deformity. Of the 34 patients who underwent TT fusion, 20 patients showed deformities (ankle equinus, 2; tibia procurvatum, 6; hindfoot valgus, 7; hindfoot varus, 3; and tibia procurvatum

Table 3. Postoperative Complications

Complication	Number of patients
Infection	8
Deformity	
TT fusion	
Ankle equinus	2
Tibia procurvatum	6
Hindfoot valgus	7
Hindfoot varus	3
Tibia procurvatum & hindfoot varus	2
TTC fusion	
Ankle equinus	2
Tibia procurvatum	1
Hindfoot valgus	0
Hindfoot varus	0
Tibia procurvatum & hindfoot varus	0
Delayed union	0

TT: tibiotalar, TTC: tibiotalocalcaneal.

accompanied by hindfoot varus, 2). Out of the 7 patients who underwent TTC fusion, 3 patients had deformities (ankle equinus, 2; tibia procurvatum, 1) (Table 3).

DISCUSSION

Several studies noted an increased incidence of adjacent joint arthritis after an ankle fusion.[9-11] Coester et al.[9] performed a long-term follow-up study of 22 years after an isolated ankle fusion and found that osteoarthritis of the ipsilateral subtalar, talonavicular, calcaneocuboid, naviculocuneiform, tarsometatarsal, and first metatarsophalangeal joints was significantly more severe than that on the contralateral side. Fuchs et al.[10] also reported development of adjacent joint arthritis in their 20-year follow-up study after ankle arthrodesis.Following an ankle fusion, the triceps muscle would act as an inverter on the subtalar joint, which would progressively transform its shock-absorbing valgus properties into a rigid, varus disposition.[12] Furthermore, a varus subtalar joint blocks compensatory sagittal plane motion of the midtarsal joints.[13] Eventually, abnormally altered loading of the adjacent joint after ankle fusion is believed to exacerbate development of osteoarthritis.

On the other hand, some argue that adjacent joint arthritis may not be a by-product of ankle fusion, but rather a development of preexisting degenerative changes in this joint. Sheridan et al reviewed preoperative radiographs of patients who underwent ankle fusion and found that most showed preexisting arthritis in the subtalar or midtarsal joint.[14] In addition, in their 3-dimensional biomechanical study that compared a normal foot and a foot with ankle fusion, Wang et al.[15] reported that the contact pressure and transferred force at the subtalar joint were rather decreased in a foot with ankle fusion. Afterall, it can be speculated that the consequence in the adjacent joints after ankle fusion has yet to be identified.

The patients in this study underwent TT or TTC fusion using an Ilizarov external fixator for substantial bone defects around the ankle joint. At 5.71 years of follow-up after external fixator removal, adjacent joint fusion was achieved spontaneously in 88.3% of the patients who underwent TT fusion and in 100% of those with TTC fusion. Although the actual mechanism that led to the spontaneous adjacent joint fusion is not clear, restriction of midfoot motion using an external fixator that crosses the subtalar or midtarsal joint may have eliminated the influence of altered joint loads. Future experimental researches that could validate spontaneous adjacent joint fusion following TT or TTC fusion would be needed.

This study has some limitations. First, it is a retrospective case series study, with no control group for comparison. Second, there are no clinical data available in this study. If patient-reported outcomes had been accompanied, it would have been possible to interpret actual clinical effect of the distinct radiographic results of this study. Lastly, the midtarsal joint was not divided in detail. As the midtarsal joint is composed of the calcaneocuboid and talonavicular joints, their respective analysis may have enhanced the quality of this work. Nevertheless, we believe that this study is valuable in that it is the first study to present adjacent joint fusion at midterm follow-up following TT or TTC fusion.

In this study, we observed spontaneous adjacent joint fusion following TT or TTC fusion using an Ilizarov external fixator for substantial bone defects around the ankle joint. Although a careful approach should be made since patients treated in this study may not represent typical candidates that need primary joint-sacrificing procedures, we believe that this study may draw attention from surgeons concerned about the fate of the adjacent joint status after TT or TTC fusion.

CONFLICT OF INTEREST

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

ACKNOWLEDGEMENTS

This study was supported by Hallym University Research Fund, Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2020R1I1A3074575) and "Regional Innovation Strategy (RIS)" through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (MOE) (2022RIS-005).

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