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Ankle syndesmotic injuries: short-term radiological outcomes and complications following tightrope fixation

Sanjay Jain, Abhishek Harsoor, Rama Mohan

Department of Trauma and Orthopaedics, North Manchester General Hospital, Delaunays Road, Manchester, UK

Abstract

Introduction: Ankle syndesmotic injuries are complex and require accurate reduction and stabilisation to restore normal ankle biomechanics. While traditional screw fixation is widely used, it carries risks such as screw loosening, breakage, and the need for secondary removal. The suture-button Tightrope system offers dynamic stabilisation and facilitates earlier mobilisation. This study aimed to evaluate radiographic stability and complications associated with the ankle Tightrope technique for ankle syndesmotic injuries at our institution.

Methods: We retrospectively reviewed 83 patients (mean age, 41.3 years) who underwent ankle Tightrope fixation for syndesmotic disruption between 2013 and 2023. Demographic data, injury characteristics, procedural details, radiographic parameters, and complications were systematically analysed.

Results: Tightrope fixation demonstrated a statistically significant improvement in syndesmotic parameters (MCS, TFO and TFCS), maintained throughout follow-up. Most patients achieved early weight-bearing within 6 weeks with a prolonged median follow-up of 20.4 weeks. The overall complication rate was 13.2%, with very low incidences of infection, device migration, button malposition, and syndesmotic diastasis. There were no cases of aseptic osteolysis, peri-implant fracture, or revision fixation.

Conclusions: Tightrope fixation provides a reliable, safe, and minimally invasive alternative to screw fixation for syndesmotic injuries, maintaining anatomical reduction with low complication rates. Its use facilitates early weight-bearing and accelerated rehabilitation, providing a reproducible and effective strategy for both isolated and fracture-associated syndesmotic disruptions.

Keywords

Ankle fractures; tightrope fixation; radiographic outcome; complications

Corresponding author

Sanjay Jain
drjains@hotmail.com

Introduction

Ankle fractures are a common orthopaedic injury in England and Wales, with an estimated annual incidence of at least 15 cases per 10,000 people.[1] About 13% of ankle fractures and 0.5% of ankle injuries without fracture are associated with distal tibiofibular syndesmotic injury, which, if left untreated, can result in ankle instability, chronic pain, and post-traumatic arthritis.[2,3] Accurate diagnosis, anatomical reduction, and stable fixation of the syndesmosis are essential to promote healing of the syndesmotic complex and to restore anatomy, biomechanics and normal function of the ankle. The optimal technique for syndesmotic stabilisation remains debated. Traditionally, rigid fixation with cortical screws has been standard; however, screw loosening, breakage, and the need for secondary removal are frequent issues. Also, Prolonged immobilisation and non-weight bearing or protected weight bearing can be associated with morbidity.

Furthermore, premature removal of screws before ligament healing increases the risk for ankle diastasis. The fibre-wire Tightrope system (Arthrex, Inc., USA) has emerged as a viable alternative to conventional screw fixation, offering biomechanical advantages and the potential for earlier postoperative mobilisation. However, Tightrope fixation is associated with its own complications.

This study aims to investigate the radiographic outcomes and complication rates associated with Tightrope fixation for syndesmotic injuries treated at our institution over a ten-year period.

Materials and methods

We retrospectively reviewed all cases (>16 years) of acute isolated ankle syndesmotic injury, either alone or in combination with an ankle fracture, treated with Arthrex ankle Tightrope at our institution between November 2013 and August 2023. A total of 91 patients were treated during this period. Exclusion criteria included inadequate medical records, insufficient imaging, clinical follow-up of less than 12 weeks, open fractures, uncontrolled diabetes, peripheral neuropathy, and pathological fractures. Details of excluded patients were as follows: 2 had inadequate medical records, 2 had inadequate imaging, 3 cases had follow-up less than 12 weeks, and one patient had an open fracture. Finally, 83 patients were eligible for inclusion in the current study.

Syndesmotic diastasis was defined by tibiofibular clear space (TFCS) >6 mm on anteroposterior or mortise radiograph, tibiofibular overlap (TFO) <6 mm on anteroposterior radiograph 10 mm proximal to the tibial plafond, or <1 mm on mortise radiograph, or medial clear space (MCS) greater than the superior joint space or >5 mm on anteroposterior radiograph.[4,5] Diagnosis of syndesmotic disruption was confirmed using preoperative plain radiographs and intraoperative fluoroscopic assessment, evaluating TFCS, TFO, and MCS parameters.

Surgical technique

All procedures were performed with the patient in the supine position under either general or regional anaesthesia, using a thigh tourniquet. Fracture fixation followed AO-ASIF principles. Fibular fractures were addressed first, typically using a one-third tubular plate or locking plate, with or without lag screws. In cases of high fibular fractures (>15 cm proximal to the tip of the lateral malleolus), syndesmotic fixation alone was performed. Medial malleolar fractures were stabilised using partially threaded cancellous screws or a tension band wire (TBW) construct. Assessment for syndesmotic injury was conducted intraoperatively utilising a combination of the hook test, stress dorsiflexion, and external rotation manoeuvres, with radiographic evaluation of medial clear space (MCS), tibiofibular overlap (TFO), and tibiofibular clear space (TFCS) under image intensification. When syndesmotic widening was identified, stabilisation was achieved using the Arthrex Tightrope fixation system, applied through the fibular plate in accordance with the manufacturer's recommended technique.[6] In most cases, Tightrope fixation was performed through two or three holes of a one-third tubular plate, particularly in isolated syndesmotic injuries or Maisonneuve-type fractures. The number of Tightropes used was determined at the discretion of the operating surgeon.

Post-operative management

Wound sutures were removed at two weeks post-operatively. All patients were immobilised in below-knee casts or protective boots and instructed to remain non-weight-bearing for six weeks. This was followed by a structured physiotherapy programme focusing on ankle range of motion, proprioceptive training, and gradual progression to full weight-bearing as tolerated, subject to satisfactory radiographic evaluation. Clinical assessments and weight-bearing radiographs were performed during follow-up visits in the fracture clinic.

Table 1. Demographics and patient summary results

Demographics	**Results** **Number/%/Mean/range/+/- SD** **(N=83)**
Age	Mean 41.33 (range 17-73 years)
Sex	
Men	48 (57.8%)
Women	35 (42.2%)
Side	
Right	38 (45.8%)
Left	45 (54.2%)
Smoker	30 (36.1%)
Diabetic	7 (8.4%)
ASA	
1	52 (62.7%)
2	28 (33.7%)
3	3 (3.6%)
BMI	30.35 (range 19-44.2)
Injury pattern	
Weber B fractures	17 (20.5%),
Weber C fractures	52 (62.7%)
Bimalleolar fractures	25 (30.1%)
Trimalleolar fractures	2 (2.4%)
Unimalleolar fractures	47 (56.6%)
Maisonneuve fractures	4 (4.8%)
Pure syndesmotic injury	5 (6%)
Injury surgery interval	4.16 days (range 1-25 days)

Radiographic Findings-(mm)	
Pre-op	
MCS	6.13+/-1.95
TFO	1.87+/-2.77
TFCS	7.87+/-1.71
Initial post Op-	
MCS	2.70+/-0.67
TFO	6.68+/-0.57
TFCS	4.71+/-0.66
Final follow up	
MCS	2.80+/-0.67
TFO	6.56+/-0.54
TFCS	4.86+/-0.67
No of Tightrope	
Single Tightrope	53 (63.9%)
Double Tightrope	30 (36.1%)
Distance from the tibial plafond	
Single tightrope	17.65 mm (range 7.1mm-32.3mm)
Double Tightrope	12.3 mm(range 7.1 mm-20.1mm) and 26.3 (range 15.7mm-38.6 mm).
Time to full weight bearing	6.01 weeks (range 5-8 weeks)
Post operative Immobilisation	
Cast	81 (97.6%)
Boot	2 (2.4%)
Formal Physiotherapy	54 (65.1%)
Ankle Exercise leaflets provided only	29 (34.9%)
Follow up	20.35 weeks (range 12-88 weeks).

Abbreviations: MCS – Medial clear space; TFO – Tibiofibular overlap; TFCS – Tibiofibular clear space.

Radiographic analysis included preoperative, initial postoperative, and final follow-up weight-bearing anteroposterior views, with measurements of medial clear space (MCS), tibiofibular overlap (TFO), and tibiofibular clear space (TFCS). The integrity of the Tightrope construct was assessed by comparing these parameters between the initial postoperative and final follow-up radiographs. A change in syndesmotic width exceeding 2 mm was considered the threshold for clinically significant widening.[7,8,9] All measurements were performed using digital radiographic software (PACS/Sectra).

Medical, operative, and radiographic records were systematically reviewed. Data collected included patient demographics, ASA classification, body mass index (BMI), smoking status, injury type, fracture pattern, associated comorbidities, time interval from injury to surgery, operative details, number of Tightropes used, distance of Tightrope placement from the ankle plafond, methods of fracture fixation, postoperative immobilisation protocol, weight-bearing status, physiotherapy involvement, duration of follow-up, and documented complications.

The recorded complications included infection, revision surgery, suture button removal, persistent unexplained pain, re-diastasis or syndesmotic widening, knot irritation, osteolysis, medial button malposition, and intraosseous migration of the lateral or medial button.

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 31.0. A p-value <0.05 was considered statistically significant. Comparisons between groups were made using the two-sample independent *t*-test.

Results

A total of 83 patients were included in the study, comprising 48 males (57.8%) and 35 females (42.2%), with a mean age of 41.3 years (range: 17–73 years). The left ankle was affected in 45 cases (54.2%) and the right in 38 cases (45.8%). Thirty patients (36.1%) were regular smokers, and seven patients (8.4%) had diabetes. The majority were classified as ASA grade I or II (96.4%). Details of injury patterns are shown in Table 1. The most common fracture configurations were Weber C (52 patients, 62.7%) and unimalleolar fractures (47 patients, 56.6%). Pure syndesmotic injuries without associated fracture were observed in only five patients (6%). The mean body mass index (BMI) was 30.35 (range: 19–44.2). The average interval between injury and surgery was 4.16 days (range: 1–25 days). A single Tightrope device (Figure 1) was used in 53 cases (63.9%), while double Tightrope (Figure 2) fixation was employed in 30 cases (36.1%). In single Tightrope cases, the mean distance from the tibial plafond was 17.65 mm (range: 7.1–32.3 mm). For double Tightrope constructs, the mean distances were 12.3 mm (range: 7.1–20.1 mm) and 26.3 mm (range: 15.7–38.6 mm), respectively. The mean time to full weight-bearing was 6.01 weeks (range: 5–8 weeks). Postoperative immobilisation included below-knee casts in 81 patients and protective boots in 2 patients. Formal physiotherapy was undertaken by 54 patients (65.1%). The average follow-up duration was 20.35 weeks (range: 12–88 weeks). A comprehensive summary of demographics and clinical variables is provided in Table 1.

Radiographic measurements of medial clear space (MCS), tibiofibular overlap (TFO), and tibiofibular clear space (TFCS) were evaluated at three time points: preoperatively, initial postoperative period, and at final follow-up. The mean preoperative values were 6.13 ± 1.95 mm (MCS), 1.87 ± 2.77 mm (TFO), and 7.87 ± 1.71 mm (TFCS). Following Tightrope fixation, initial postoperative measurements showed significant improvement across all parameters: MCS decreased to 2.70 ± 0.67 mm, TFO increased to 6.68 ± 0.57 mm, and TFCS decreased to 4.71 ± 0.66 mm. These changes were statistically significant ($p < 0.001$ for all), confirming effective syndesmotic reduction. (Table 2) Also, at final follow-up, weight-bearing radiographs demonstrated sustained stability. The mean values were 2.80 ± 0.67 mm (MCS), 6.56 ± 0.54 mm (TFO), and 4.86 ± 0.67 mm (TFCS). Comparison between initial postoperative and final follow-up measurements revealed no statistically significant differences: MCS increased by 0.10 mm ($p = 0.33$), TFO decreased by

Table 2. Comparison of MCS, TFO and TFCS between preoperative and initial post-op (n = 83)				
	Preoperative (mm)	**Initial postoperative (mm)**	**Mean Difference (mm)**	***P*-value**
MCS	6.13 ± 1.95	2.70 ± 0.67	–3.43	<0.001
TFO	1.87 ± 2.77	6.68 ± 0.57	+4.81	<0.001
TFCS	7.87 ± 1.71	4.71 ± 0.66	–3.16	<0.001

Note: Values are expressed as mean ± standard deviation. *P*-values calculated using a paired *t*-test.

Table 3. Comparison of MCS, TFO and TFCS between initial post-op and final follow-up (n = 83)				
	Initial Post op (mm)	**Final Follow up (mm)**	**Mean Difference (mm)**	**P value**
MCS	2.70+/-0.67	2.80+/-0.67	0.10	0.33
TFO	6.68+/-0.57	6.56+/-0.54	0.12	0.165
TFCS	4.71+/-0.66	4.86+/-0.67	0.15	0.149

Table 4. Complications of ankle Tightrope fixation	
Complications	**No (%)**
Overall complication	**11 (13.2%)**
Knot/suture irritation	1 (1.2%)
Infection	
-Superficial	1 (1.2%)
-Deep/osteomyelitis	1 (1.2%)
Re diastasis/widening of syndesmosis	1 (1.2%)
Removal of suture button due to problem with button	2 (2.4%)
Medial intraosseous migration button	1 (1.2%)
Lateral intraosseous migration button	1 (1.2%)
Malposition of medial endobutton	2 (2.4%)
Unexplained chronic pain	1 (1.2%)

0.12 mm ($p = 0.165$), and TFCS increased by 0.15 mm ($p = 0.149$). All changes remained within the accepted threshold of ≤2 mm, indicating durable syndesmotic fixation throughout the follow-up period. (Table 3)

The overall complication rate directly attributable to Tightrope fixation was 13.2%. Knot irritation on the lateral aspect was reported in one patient (1.2%), and one patient (1.2%) developed a superficial infection at the knot site, which was successfully treated with oral antibiotics. One patient (1.2%) experienced a deep in-

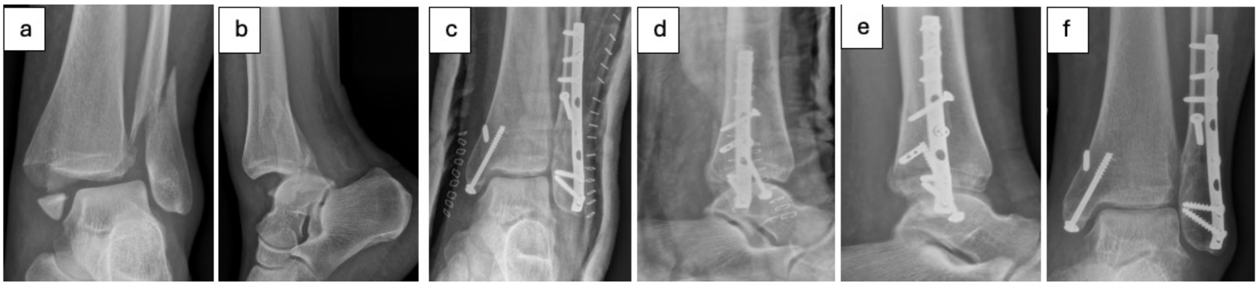

Figure 1: *X-ray images of a patient with the tri-malleolar ankle fracture dislocation associated with syndesmosis injury fixed with a single Tightrope: Preoperative (a, b), Early Postoperative (c, d), and Final Follow-up (e, f).*

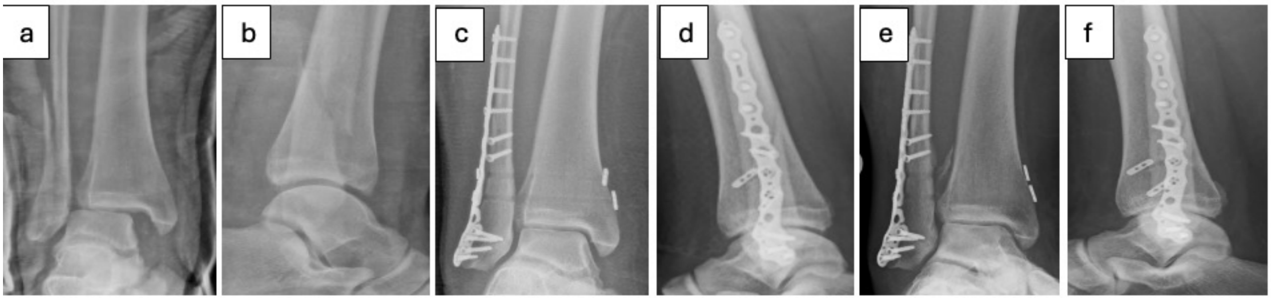

Figure 2: *X-ray images of a patient with the bimalleolar ankle fractures associated with syndesmosis injury fixed with a Double Tightrope: Preoperative (a, b), Early Postoperative (c, d), and Final Follow-up (e, f).*

fection that required surgical debridement and removal of both the Tightrope and the associated metalwork. Migration of the suture button was observed in two cases: one (1.2%) with intraosseous lateral migration in a patient where a Tightrope was applied without a fibular plate, and one (1.2%) with intraosseous medial migration. Malposition of the medial Endobutton occurred in two patients (2.4%). None of the patients with minimal intraosseous migration had any syndesmotic widening or diastasis. One patient (1.2%) reported persistent unexplained ankle pain, and another (1.2%) developed syndesmotic diastasis, which was managed conservatively as the patient declined revision surgery. Tightrope removal was performed in two patients (2.4%): one due to deep infection at 11 months and the other due to knot irritation at 12 months. In both cases, wound healing was uneventful post-removal, and no syndesmotic widening or residual pain was noted at final follow-up. A detailed summary of complications is presented in Table 4. There were no cases of aseptic osteolysis, peri-implant fracture, or revision fixation. Additionally, one patient underwent removal of all metalwork, including the Tightrope, due to a prominent fibular plate—this was not directly related to the Tightrope device. Three patients with Weber C fractures experienced chronic ankle pain attributed to underlying osteoarthritis rather than implant-related complications. Two patients reported moderate ankle stiffness during early follow-up, which resolved with physiotherapy.

Discussion

Ankle fractures associated with syndesmotic disruption are complex injuries that require accurate recognition, anatomical reduction, stable fixation, and progressive rehabilitation to optimise long-term outcomes and reduce the risk of post-traumatic degenerative arthritis. Despite their clinical importance, there is no established consensus on the optimal management of these injuries. Traditionally, metallic screw fixation has been the preferred method for syndesmotic stabilisation. However, the literature reflects considerable variability regarding screw type, size, number, positioning, cortical engagement, and protocols for removal, including timing and necessity.[2,3] Moreover, screw fixation is associated with several complications, including excessive rigid fixation, screw loosening (up to 20%), breakage (up to 28%), syndesmotic malreduction (reported as high as 52%), and the need for prolonged protected weight-bearing.[10–12]

Ankle Tightrope fixation devices have gained considerable popularity over the past 10–15 years. This low-profile system, implanted across the syndesmosis via a minimally invasive approach, offers dynamic stabilisation that accommodates physiological micromotion while maintaining accurate reduction. Compared to screw fixation, Tightrope devices provide effective resistance to diastasis, facilitate earlier weight-bearing, eliminate the need for routine implant removal, reduce malreduction rates, and are associated with an earlier return to work and improved functional outcomes.[10, 14–16]

Tightrope fixation demonstrated reliable radiographic and clinical outcomes in our cohort. Postoperative improvements in medial clear space (MCS), tibiofibular overlap (TFO), and tibiofibular clear space (TFCS) were statistically significant and sustained at final follow-up. Displacement between initial postoperative and final weight-bearing radiographs (MCS 0.10 mm, TFO 0.12 mm, TFCS 0.15 mm) remained well below thresholds for syndesmotic widening, indicating robust fixation and preserved reduction. These findings are consistent with current literature. Long-term data from Grassi et al. and Ræder et al. support the durability of suture button constructs and their association with reduced reoperation rates.[17,18] Migliorini et al. reported superior functional outcomes, fewer complications, and lower malreduction rates compared to screw fixation.[19] Fabião et al. confirmed sustained radiographic stability in isolated syndesmotic injuries.[20] Anand et al. observed a satisfactory reduction in 97% of Weber C fractures treated with Tightrope, further validating its radiographic reliability.[21]

The mean time to full weight-bearing in our cohort was 6.01 weeks, with 65.1% of patients receiving formal physiotherapy. Voight et al. reported return-to-sport timelines of less than eight weeks following Tightrope fixation combined with a structured rehabilitation programme.[22] The dynamic nature of suture button constructs allows early mobilisation without compromising stability, offering a distinct advantage over screw-based fixation, which often necessitates delayed weight-bearing and implant removal. Patel et al. further demonstrated that hybrid fixation incorporating suture buttons restores tibiofibular kinematics and supports safe early mobilisation.[23] Biomechanical evidence from Wixted et al. confirms the mechanical reliability of Tightrope fixation in resisting syndesmotic diastasis under physiological loads.[24]

Complications in our series were infrequent and manageable, with an overall rate of 13.2%. Suture button removal was required in only two cases (2.4%) due to infection and knot irritation; both resolved without persistent syndesmotic widening. Schepers et al. reported a 10% implant removal rate, primarily due to soft tissue irritation from prominent suture knots.[25] Degroot et al. noted a higher complication rate of 25%, necessitating removal in several cases.[16] Across the literature, the incidence of soft tissue irritation ranges from 5.6% to 21%.[3,14] This complication can be mitigated by surgical technique—specifically, trimming the fibre wire 1 cm beyond the knot and burying the end adjacent to the fibula. Notably, knot irritation is uncommon with the use of modern knotless Tightrope implants. In our series, complications related to infection were limited. One patient (1.2%) developed a superficial wound infection, successfully managed with oral antibiotics, while another (1.2%) experienced a deep infection requiring surgical debridement and suture button removal. Naqvi et al. reported a 6.1% infection rate among 49 patients, all necessitating implant removal.[14] Storey et al. documented a broader spectrum of complications, including 3% superficial wound infection, 3% osteomyelitis, and 2% aseptic osteolysis.[26] In their cohort, Tightrope removal was performed in 8% of cases for reasons including osteomyelitis, radiological track widening with pain, failed syndesmotic stabilisation, and unexplained discomfort. These findings highlight the importance of meticulous surgical technique and postoperative monitoring to minimise implant-related complications.

We reported a total of 2.4% incidence of intraosseous migration and 2.4% of a malposition of the medial button, but none of them had any diastasis of the syndesmosis**.** Storey et al. documented 3% intraosseous migration of the lateral endobutton, 1.9% diastasis, and 3% malpositioning of the medial Endobutton.[26] We had a 1.2 % incidence of diastasis and a 1.2% unexplained chronic pain. Device malpositioning and migration can both lead to diastasis of the syndesmosis.. In our cohort, there were no cases of aseptic osteolysis, peri-implant fracture, or revision fixation.

In our cohort, intraosseous migration and malpositioning of the medial endobutton were each observed in 2.4% of cases, with no associated widening of the syndesmosis. Storey et al. reported complication rates including 3% intraosseous migration of the lateral endobutton, 3% malpositioning of the medial endobutton, and 1.9% syndesmotic diastasis, with a notable proportion of patients requiring implant removal due to complications such as osteomyelitis and aseptic osteolysis.[26] These rates are comparable to those observed in the present study. In our series, diastasis was observed in only 1.2% of cases. Wixted et al. confirmed the biomechanical reliability of suture button constructs across varying configurations but emphasised that malposition may compromise fixation integrity and predispose to syndesmotic instability.[24] In contrast, Fabião et al. reported no cases of migration or diastasis in their cohort of isolated syndesmotic injuries treated with Tightrope, demonstrating sustained radiographic stability over mid-term follow-up.[20] We recommend a small medial incision to ensure accurate placement of the medial endobutton directly onto the tibial cortex. This technique prevents soft tissue interposition between the endobutton and cortex, thereby reducing the risk of malposition, construct loosening, and subsequent syndesmotic diastasis. To enhance lateral stability, we also advocate passing the Tightrope through the fibular plate. In cases such as isolated syndesmotic injuries or high fibular fractures, where a lateral plate may not otherwise be indicated, a two- or three-hole one-third tubular plate can be used to support the lateral Endobutton. This construct has proven effective in minimising lateral button migration and maintaining syndesmotic integrity throughout rehabilitation. In our series, there were no cases of aseptic osteolysis, peri-implant fracture, or revision fixation.

Collectively, these findings underscore the importance of meticulous implant positioning and reinforce the reproducibility and safety of Tightrope fixation when executed with precise surgical technique.

This study has several notable strengths. 1. It includes a robust cohort of 83 patients, providing a meaningful sample for evaluating outcomes following syndesmotic fixation. 2. Radiographic assessment was comprehensive, with serial measurements of medial clear space (MCS), tibiofibular overlap (TFO), and tibiofibular clear space (TFCS) obtained at preoperative, initial postoperative, and final follow-up intervals—offering objective evidence of reduction quality and maintenance. 3. The study reflects real-world orthopaedic practice, incorporating a range of injury patterns, ASA classifications, and rehabilitation protocols, thereby enhancing external validity. 4. Additionally, the moderate-term follow-up period allowed for the evaluation of both early and short-term outcomes.

However, our study has several limitations. 1.It was conducted at a single centre, which may introduce bias related to institutional surgical practices and variability in clinical documentation. 2. The non-randomised design limits statistical power for subgroup analysis and prevents causal inference. 3. Differences in surgical technique among operating surgeons could have influenced outcomes. 4. Some patients may have continued their care outside the institution, potentially leading to missed complications or reoperations. 5. The final follow-up did not include standardised assessments of ankle strength, range of motion, or validated functional outcome scores, making it difficult to evaluate the clinical impact of complications fully. 6. Additionally, heterogeneity in postoperative care—particularly in immobilisation methods and physiotherapy protocols—may have affected recovery. Nonetheless, the primary objective of this study was to assess radiographic outcomes and complications rather than functional outcomes.

Conclusions

Accurate anatomical reduction and stabilisation are essential for achieving optimal long-term outcomes in syndesmotic injuries. Ankle Tightrope fixation provides a minimally invasive, biomechanically stable alternative to traditional screw fixation. Careful surgical technique ensures safe, durable, and reproducible outcomes with minimal need for revision. Our experience demonstrates excellent radiographic outcomes and a low complication rate, allowing early weight-bearing and rehabilitation while preserving syndesmotic stability.

Conflict of Interest

The authors declared no conflicts of interest.

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