AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International®
2014, Vol. 35(6) 543–548

DOI: 10.1177/1071100714524552
fai.sagepub.com

The Effect of Syndesmosis Screw Removal on the Reduction of the Distal Tibiofibular Joint: A Prospective Radiographic Study

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Abstract

Background: Injury to the tibiofibular syndesmosis is frequent with rotational ankle injuries. Multiple studies have shown a high rate of syndesmotic malreduction with the placement of syndesmotic screws. There are no studies evaluating the reduction or malreduction of the syndesmosis after syndesmotic screw removal. The purpose of this study was to prospectively evaluate syndesmotic reduction with CT scans and to determine the effect of screw removal on the malreduced syndesmosis.

Methods: This was an IRB-approved prospective radiographic study. Patients over 18 years of age treated at 1 institution between August 2008 and December 2011 with intraoperative evidence of syndesmotic disruption were enrolled. Postoperative CT scans were obtained of bilateral ankles within 2 weeks of operative fixation. Syndesmotic screws were removed after 3 months, and a second CT scan was then obtained 30 days after screw removal. Using axial CT images, syndesmotic reduction was evaluated compared to the contralateral uninjured ankle. Twenty-five patients were enrolled in this prospective study. The average age was 25.7 (range, 19 to 35), with 3 females and 22 males.

Results: Nine patients (36%) had evidence of tibiofibular syndesmosis malreduction on their initial postoperative axial CT scans. In the postsyndesmosis screw removal CT scan, 8 of 9 or 89% of malreductions showed adequate reduction of the tibiofibular syndesmosis. There was a statistically significant reduction in syndesmotic malreductions ($t = 3.333$, $P < .001$) between the initial rate of malreduction after screw placement of 36% (9/25) and the rate of malreduction after all screws were removed of 4% (1/25).

Conclusions: Despite a high rate of initial malreduction (36%) after syndesmosis screw placement, 89% of the malreduced syndesmoses spontaneously reduced after screw removal. Syndesmotic screw removal may be advantageous to achieve final anatomic reduction of the distal tibiofibular joint, and we recommend it for the malreduced syndesmosis.

Level of Evidence: Level IV, prognostic case series.

Keywords: syndesmosis, syndesmosis malreduction, ankle fracture

Syndesmosis disruptions are common with rotational ankle injuries. These disruptions occur in up to 13% of patients with ankle fractures and up to 0.5% in patients with ankle sprains.[1] Untreated syndesmosis injuries can result in tibiofibular instability, pain, and limited activity.[1] In 2006, Gardner et al showed a 52% malreduction of the tibiofibular syndesmosis after syndesmotic screw fixation on CT scans in their 25-patient cohort.[3] Multiple authors have correlated the quality of syndesmotic reduction of with improved functional outcomes.[7,10,12]

To our knowledge, no study has been performed to investigate the effect of syndesmotic screw removal on the malreduced syndesmosis. Anecdotal experience has shown a change in the anatomy of the distal tibiofibular joint after syndesmotic screw removal when looking for additional pathology on advanced imaging for patients with continued pain after ankle fracture fixation. The purpose of this study was to both prospectively evaluate syndesmotic reduction

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with CT scans and determine the effect of screw removal on the malreduced syndesmosis.

We hypothesized that we would find a high rate of malreduction of the distal tibiofibular joint after syndesmotic screw placement, but that many would improve after syndesmotic screw removal.

Methods

This study protocol was approved by the Human Use Committee. This was a prospective radiographic study conducted at 1 institution from August 2008 to December 2011. Patients were evaluated for possible syndesmosis injury in association with ankle fractures. Patients were assessed intraoperatively for syndesmosis instability after appropriate malleolar fixation using the Cotton test or external rotation test or both. Patients who required stabilization with a syndesmotic screw were eligible for enrollment into the study. After informed consent was obtained, patients greater than 18 years of age with intraoperative evidence of syndesmosis injury were enrolled. Exclusion criteria included concomitant ipsilateral lower extremity trauma, previous ankle fracture, skeletal immaturity, medical comorbidities limiting operative options, and pregnancy.

As no accepted standard has been established in the literature, mode of fixation (screw size, number of screws, cortices) was left to the discretion of the operative surgeon. Large reduction clamps were used to aid in syndesmotic reduction. Presumed adequate reduction of the malleolar fractures and the distal tibiofibular syndesmosis joint was verified with both intraoperative fluoroscopy and immediate postoperative portable radiographs. Patients underwent bilateral axial CT scans within 2 weeks of operative fixation. Standard postoperative rehabilitation was initiated to include 3 months of non-weight-bearing, and syndesmotic screws were removed 3 months postoperatively. A final axial CT scan was obtained greater than 1 month after the syndesmotic screw was removed. All CT scans were obtained per the radiology department's protocol with the ankle in neutral dorsiflexion.

Twenty-five patients were enrolled in this prospective study. The average age was 25.7 (range, 20 to 35) years, with 3 females and 22 males. There were 10 different attending surgeons involving in the operative care of the enrolled patients. Eight patients had Weber B fractures, 13 patients had Weber C fractures, 4 patients had Maisonneuve fractures, 2 patients had associated medial malleolus fractures, and 5 patients had associated posterior malleolus fractures. All patients had transsyndesmotic screws. Twenty-two patients underwent syndesmosis fixation with 1 screw and 3 patients underwent fixation with 2 screws. Three patients had 3.5 mm screws placed, while the rest of the patients had 4.5 mm screws placed. Eight patients had 3 cortices per screw, while 17 patients had 4 cortices per syndesmotic screw (Table 1). Anatomic reduction of the fracture pattern(s) was verified intraoperatively with fluoroscopy and with portable radiographs immediate postoperatively. Syndesmotic screws were removed on an average of 107 days.

All CT scans were reviewed independently by 1 senior orthopaedic surgery resident, 1 foot and ankle fellowship-trained board-certified orthopaedic surgeon, and 1 musculoskeletal fellowship-trained board-certified radiologist at 2 different time intervals greater than 3 months apart. As previously established by Gardner et al, axial CT scans were used to measure the distance between the fibula and the anterior and posterior incisura approximately 1 cm proximal to the joint line. As many recent studies have shown normal anatomic variants in the distal tibiofibular joint, malreduction was defined as a difference of greater than 2 mm between the anterior incisura distance of the injured and uninjured ankle or the difference of greater than 2 mm between the posterior incisura distance of the injured and uninjured ankle (Figure 1). The average of these measurements were used for data analysis. Because of the continuous nature of the measurements, Pearson's product–moment correlations were used to calculate inter- and intrarater reliability.

Statistical Analysis

Pearson chi-square and likelihood ratio tests were performed to identify any risk factors (eg, fracture pattern, screw configuration) for initial malreduction or continued malreductions, and *t* tests were used for continuous variables (ie, age). Chi-squares were also performed for contrasting the changes of malreduction rates before and after screw removal of the various fracture patterns (Weber B, Weber C, Maisonneuve). Odds ratios and relative risks were computed to quantify the difference between the rate of malreduction with syndesmotic screws in place (initial postop) and after syndesmotic screws were removed. Regression analysis was used to identify risk factors for initial malreductions. Pearson's product–moment correlation was used to determine inter- and intrarater reliabilities for the syndesmotic measurements. A P value $< .05$ was set as the minimal level to be considered statistically significant.

Results

Nine patients (36%) had evidence of distal tibiofibular syndesmosis malreduction on their initial postoperative axial CT scans. Five of the 9 patients with malreduction had a greater anterior fibular incisura distance compared to their posterior fibular incisura distance (Figure 2), indicating a posterior malreduction. Two patients had posterior fibular incisura distance greater than the anterior fibular incisura

Table 1. Patient Characteristics.

Patient	Age	Sex	Fracture Pattern	# Screws	Screw Size	Cortices	Malreduced	Continued Malreduction
1	21	M	Weber B + PM < 25%	2	3.5	4		
2	28	M	Weber C + PM < 25%	1	4.5	4		
3	20	M	Weber C	1	4.5	4	X	
4	22	M	Weber C + MM	1	4.5	4	X	
5	20	F	Weber B	1	4.5	4		
6	19	F	Weber B + PM < 25%	1	4.5	4	X	
7	33	M	Weber C	1	4.5	4		
8	24	M	Weber B + PM < 25%	1	4.5	4		
9	21	M	Weber C + MM	2	3.5	3	X	X
10	22	M	Weber C	1	4.5	4		
11	27	M	Maisonneuve	1	4.5	3		
12	21	M	Weber B	1	4.5	3		
13	29	M	Weber B + PM > 25%	1	4.5	4	X	
14	30	M	Maisonneuve	1	4.5	4		
15	24	M	Weber C	1	4.5	4	X	
16	35	M	Weber C	1	4.5	4		
17	22	M	Weber C	1	4.5	4		
18	23	F	Weber B	1	4.5	3		
19	33	M	Weber C	1	4.5	4	X	
20	38	M	Weber C	1	4.5	3		
21	23	M	Weber B	1	4.5	3		
22	20	M	Maisonneuve	1	4.5	3	X	
23	26	M	Weber C	1	4.5	4		
24	21	M	Maisonneuve	2	3.5	3		
25	41	M	Weber C	1	4.5	4	X	

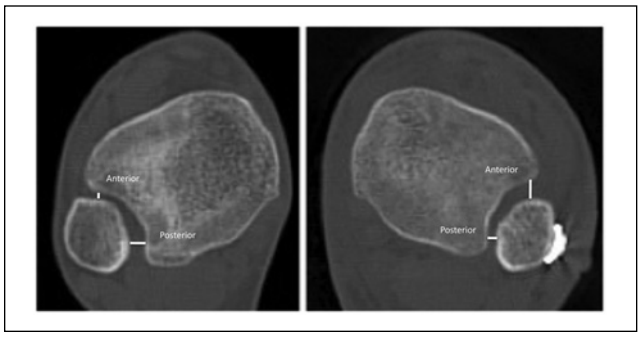

Figure 1. CT scans of a 20-year-old male with a Weber C fracture 1 cm proximal to the ankle joint showing increased anterior fibular-incisura distance between in the uninjured (left) and injured (right) ankle.

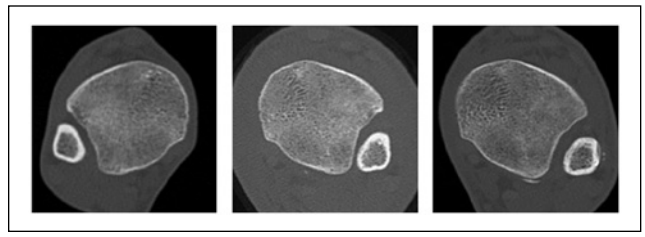

Figure 2. CT scans of a 24-year-old male with a Weber C ankle fracture treated with open reduction internal fixation of the lateral malleolus and one 4.5 mm quadricortical syndesmosis screw. Immediate postoperative CT scan (middle) shows posterior translation of the fibula with increased anterior fibular-incisura distance compared to the uninjured ankle (left). The postsyndesmosis screw removal CT (right) shows interval spontaneous reduction.

distance (Figure 3), indicating an anterior malreduction, and 1 patient had "overtightening" of the syndesmosis with greater than 2 mm reduction in both the anterior and posterior fibular incisura distance (Figure 4). Of the 9 patients with syndesmosis malreductions, 6 patients had Weber C fractures, 2 patients had Weber B fractures, and 1 patient had a Maisonneuve fracture.

In the postsyndesmosis screw removal CT scan, 8 (89%) of 9 malreductions showed spontaneous reduction of the tibiofibular syndesmosis.

One patient with continued malreduction despite screw removal was a 21-year-old male with a Weber B and medial malleolus fracture stabilized with two 3.5 mm tricortical syndesmotic screws (Figure 3). All patients with initial

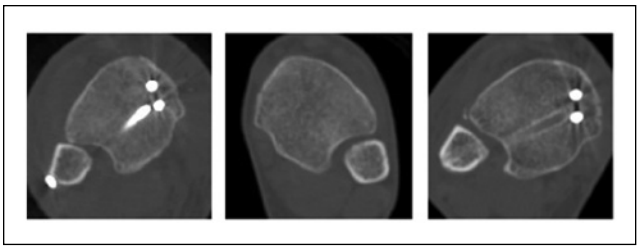

Figure 3. CT scans of a 21-year-old male with a Weber C ankle fracture with associated medial malleolus fracture treated with open reduction internal fixation including two 3.5 mm tricortical syndesmosis screws. Immediate postoperative CT scan (left) shows anterior malreduction of the operative fibula with increased posterior fibular-incisura distance compared to the uninjured ankle (middle). The postsyndesmosis screw removal CT (right) shows improved but continued malreduction with anterior translation of the fibula.

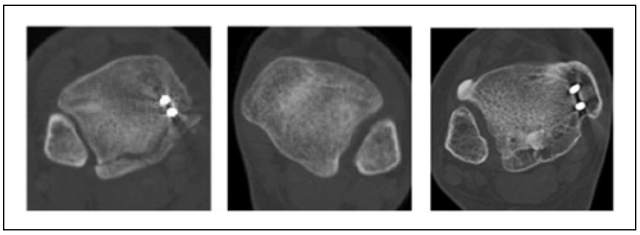

Figure 4. CT scans of a 22-year-old male with a Weber C ankle fracture with associated medial and posterior malleoli fractures treated with open reduction internal fixation including one 4.5 mm quadricortical syndesmosis screw. Immediate postoperative CT scan (left) shows overtightening of the syndesmosis with decreased anterior and posterior fibular-incisura distance compared to the contralateral ankle (middle). The postsyndesmosis screw removal CT (right) shows interval spontaneous reduction.

adequate reduction of their syndesmosis continued to have a reduced syndesmosis after screw removal.

The malreduction rate after surgery with syndesmotic screw placement was 36% (9/25). The malreduction rate subsequent to screw removal fell to 4% (1/25), constituting a statistically significant reduction in malreduction (t = 3.333, P < .001). The relative risk of leaving screws in place versus removing them was 9.00 (36%/4%, P < .001), indicating a 9-fold greater risk of malreduction when screws were not removed. The odds ratio contrasting intact syndesmotic screw versus post–screw removal was 6.00 (P < .001), indicating a 6-fold probability of a malreduction when screws were not removed.

Two of 8 (25%) Weber B fractures, 6 of 13 Weber C fractures (46.2%), and 1 of 4 (25%) Maisonneuve fractures were initially malreduced. Both patients with associated medial malleolus fractures, and 2 of 5 (40%) patients with associated posterior malleolus fractures were also initially malreduced. For Weber C fractures, the malreduction rate fell significantly from 46.2% to 7.7% with screw removal (t = 5.189, P < .001).

Pearson's product–moment correlations were calculated to determine inter- and intrarater reliability on the syndesmotic measurements. There was a strong (>.6) mean Pearson correlation for interrater reliability (.64) and intrarelability (.68). All interrater reliabilities were statistically significant (P < .05), except for the posterior fibular-incisura measurement after screw removal between rater 1 and rater 2 (r = .029, P = .891) and between rater 1 and rater 3 (r = .058, P = .782). All intrareliabilities were statistically significant (P < .05) except for the posterior fibular-incisura measurement after initial fixation for rater 1 (r = .002, P = .994).

Pearson chi-square analysis revealed no statistically significant association for age, gender, fracture pattern, screw configuration, or screw size with malreduction.

Discussion

Syndesmosis injuries are common with rotational ankle injuries and can occur with or without ankle fractures. The syndesmosis is composed of the anterior-inferior tibiofibular ligament, posterior-inferior tibiofibular ligament, interosseous ligament, interosseous membrane, and the inferior transverse ligament.[14] Egol et al showed in 2010 that patients requiring syndesmosis stabilization in addition to malleolar fracture fixation had poorer outcomes at 12 months compared to patients who required only malleolar fixation.[2]

There is significant controversy surrounding the treatment of syndesmosis injuries. A retrospective observational study at 3 university hospitals of 51 patients who underwent ankle fracture open reduction and internal fixation with syndesmosis stabilization showed that there was significant variability among surgeons regarding the technical aspect of surgery (screw size, number of screws, number of cortices, and screw removal). This study also showed that the only significantly associated factor with improved functional outcome was the anatomic reduction of the syndesmosis.[12] Multiple studies have shown no difference in outcome after syndesmotic stabilization using tricortical or quadricortical fixation.[5,8,9,13] Kukreti et al showed in their study of 36 patients that the position of the syndesmosis screw (transsyndesmotic vs suprasyndesmotic) did not indicate a significant difference in clinical and radiographic outcome.[6] In our study, there was also no statistical difference in the rate of malreduction based on different operative technique (screw size, number of screws, or number of cortices).

In a retrospective study in 2006, Gardner et al showed a 52% tibiofibular syndesmosis malreduction rate on immediate postop CT scans in their 25-patient cohort. Using axial

CT scans, they measured the distance between the fibula and the anterior and posterior incisura along a line perpendicular and 1 cm proximal to the joint. They defined malreduction as a difference greater than 2 mm between the 2 measurements.[3] In 2012, Sagi et al investigated the clinical impact of the reduction or malreduction of the syndesmosis joint after syndesmotic screw placement. At a minimum of 2-year follow-up, 39% of their patients showed evidence of malreduction on postoperative CT scans. While 44% of the syndesmotic injuries that underwent closed reduction and fixation of the syndesmosis were malreduced, only 15% of their open reduction and fixation of the syndesmosis had malreductions evident on postoperative CT scans. At a minimum of 2 years, patients with malreductions of their syndesmosis had statistically significant worse clinical outcomes on both the Short Form Musculoskeletal Assessment and Olerud/Molander questionnaires. They recommended open syndesmotic reduction to decrease the rate of malreductions and improve clinical outcomes of patients requiring syndesmotic stabilization and to obtain bilateral postoperative CT scans to evaluate the malreduction.[10] Their method of determining malreductions was different from the one described by Gardner et al. Although they used the contralateral ankle as a control, a single orthopaedic trauma surgeon evaluated the reduction and determined in a binary fashion whether the syndesmosis was reduced or malreduced.[10] All syndesmotic fixations performed in our study were performed without open reduction of the syndesmosis. Similar to Sagi et al, we had a 36% rate of malreduction after syndesmotic screw placement; however, after all syndesmotic screws were removed, our continued syndesmotic malreduction (9%) rate was lower than the open syndesmotic reduction rate (15%) in Sagi et al's study.

Another area of controversy is in defining syndesmotic malreductions. In the initial study by Gardner et al, unilateral ankle CT scans were utilized and the difference between the anterior fibular incisura and the posterior fibular incisura distance was measured. A difference of 2 mm or greater between the 2 measurements was defined as malreduced.[3] Subsequent studies have established other methods to define syndesmotic malreductions. Grenir et al established a new radiographic measurement known as the anteroposterior tibiofibular (APFT) ratio that utilizes plain radiographs intraoperatively to evaluate the syndesmotic reduction.[4] Mukhopadhyay et al also used axial CT scans, similar to Gardner et al, but used the uninjured ankle as a control to standardize measurements. They coined the term "mean diastasis," which is the average between the anterior fibular-incisura and the posterior fibular-incisura distance. A mean diastasis of greater than 2 mm was considered malreduced.[9] Sagi et al used a binary system where a single orthopaedic surgeon looked at bilateral axial ankle CT scans and evaluated for residual gaps, translation, or external rotation of the fibula to determine malreductions.[10] In our study, we used a combination of reported methods to determine syndesmotic malreductions. Using the contralateral uninjured ankle as a control, differences of greater than 2 mm of either the anterior fibular incisura or posterior fibular incisura distance were considered malreduced. Other than Sagi et al's binary system to define syndesmotic malreductions, none of the methods to define syndesmotic malreduction has been clinical validated. We believe our method adopts a combination of methods previously published in the literature and takes into account the possible normal variants of the syndesmosis joint.[9,10] With a strong inter- and intrarater reliability on Pearson's product–moment correlations, this method of determining syndesmotic malreduction has reliable reproducibility. The difficulty found with some of the posterior fibular-incisura distance measurement may be secondary to the difficulty with the presence of posterior malleoli fractures. Future studies are still required to establish a validated method to define syndesmotic malreductions.

Although it is classically believed that syndesmosis screws should be removed prior to weight-bearing to prevent screw breakage, there is controversy in the literature regarding the need for screw removal. Manjoo et al performed a retrospective study of 106 ankle fractures that underwent open reduction with internal fixation with syndesmosis stabilization, and showed that at a mean follow-up of 23 months, patients with intact screws had worse functional outcomes when compared to patients with loose, fractured, or removed screws.[7] On the other hand, a recent literature review by Schepers concluded that because of the lack of good evidence to support routine screw removal, they recommended screw removal should be reserved for screws that cause irritation or reduction in range of motion after 4 to 6 months of syndesmosis stabilization.[11] Combining the data from our study and from the study by Sagi et al that patients with adequate reduction of the syndesmosis have better clinical outcomes, we hypothesize that the improved outcome in Manjoo et al's study for patients with loose, fractured, or removed screws were secondary to the improved reduction obtained with a removed or incompetent screw.

Similar to Gardner et al, we found a high rate of tibiofibular syndesmosis malreduction rate of 36%. Despite this high rate of initial malreduction, 89% of the malreduced syndesmosis spontaneously reduced after screw removal. Gender, age, screw size, number of cortices, and the number of screws were not found to correlate with the initial risk of malreduction.

This is the only prospective study to report the effect of syndesmotic screw removal on tibiofibular syndesmosis reduction. Although we do not have clinical outcomes scores for these patients, considering the existing orthopaedic literature, we believe that patients with syndesmotic malreductions should have their syndesmotic screws removed to

improve the reduction of the syndesmosis and in theory improve their clinical outcome. Future clinical studies are needed to provide definitive recommendations, but we would recommend counseling patients to consider the risks and benefits of removing all syndesmotic screws to help obtain reduction in those patients with syndesmotic malreductions and avoid the need for bilateral ankle CT scans in patients without initial syndesmotic malreductions.

There are limitations to our study. We have a small number of patients with purely radiographic outcomes. Although there were radiographic improvements after syndesmotic screw removal, without clinical outcome data we are unable to provide definitive treatment guidelines. It is possible that even with radiographic improvements after syndesmotic screw removal, these patients may have similar outcomes to those patients with initial malreductions where the screws were not removed. Another limitation is the lack of standardization regarding syndesmotic reduction evaluation as well as potential differences in the technique of obtaining CT scans that may add variability in the level in which the measurements were made. Another limitation is the large number of orthopaedic surgeons involved in the study. This adds variability regarding diagnosis of syndesmotic disruption intraoperatively with the Cotton test or the external rotation test, operative technique, and screw configuration. Although this can be weakness to this study, we believe that the variability may provide better generalization to a community orthopaedic setting.

In conclusion, despite the high number of initial malreductions after tibiofibular syndesmosis screw stabilization, the majority of the distal tibiofibular joints returned to an anatomically reduced position after screw removal. This anatomic reduction has been shown in multiple previous studies to be the only predictor of positive functional outcome after syndesmosis injuries. Although further larger prospective randomized studies with clinical outcome data are required for definitive conclusions, syndesmotic screw removal may be advantageous to achieve final anatomic reduction of the distal tibiofibular joint, and we recommend it for the malreduced syndesmosis.

Authors' Note

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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