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Evaluation of Reduction Accuracy of Suture-Button and Screw Fixation Techniques for Syndesmotic Injuries

Onur Kocadal, MD[1], Mehmet Yucel, MD[2], Murad Pepe, MD[1], Ertugrul Aksahin, MD[3], and Cem Nuri Aktekin, MD[1]

Abstract

Background: Among the most important predictors of functional results of treatment of syndesmotic injuries is the accurate restoration of the syndesmotic space. The purpose of this study was to investigate the reduction performance of screw fixation and suture-button techniques using images obtained from computed tomography (CT) scans.

Methods: Patients at or below 65 years who were treated with screw or suture-button fixation for syndesmotic injuries accompanying ankle fractures between January 2012 and March 2015 were retrospectively reviewed in our regional trauma unit. A total of 52 patients were included in the present study. Fixation was performed with syndesmotic screws in 26 patients and suture-button fixation in 26 patients. The patients were divided into 2 groups according to the fixation methods. Postoperative CT scans were used for radiologic evaluation. Four parameters (anteroposterior reduction, rotational reduction, the cross-sectional syndesmotic area, and the distal tibiofibular volumes) were taken into consideration for the radiologic assessment. Functional evaluation of patients was done using the American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot scale at the final follow-up. The mean follow-up period was 16.7 ± 11.0 months, and the mean age was 44.1 ± 13.2.

Results: There was a statistically significant decrease in the degree of fibular rotation ($P = .03$) and an increase in the upper syndesmotic area ($P = .006$) compared with the contralateral limb in the screw fixation group. In the suture-button fixation group, there was a statistically significant increase in the lower syndesmotic area ($P = .02$) and distal tibiofibular volumes ($P = .04$) compared with the contralateral limbs. The mean AOFAS scores were 88.4 ± 9.2 and 86.1 ± 14.0 in the suture-button fixation and screw fixation group, respectively. There was no statistically significant difference in the functional ankle joint scores between the groups.

Conclusion: Although the functional outcomes were similar, the restoration of the fibular rotation in the treatment of syndesmotic injuries by screw fixation was troublesome and the volume of the distal tibiofibular space increased with the suture-button fixation technique.

Level of Evidence: Level III, retrospective comparative study.

Keywords: syndesmosis, screw, suture-button, ankle

Introduction

The syndesmotic ligament complex is one of the important dynamic supporters of the ankle joint.[25] Syndesmotic injuries accompany roughly 13% of all ankle joint fractures.[3,15] Isolated syndesmotic injuries are frequently treated using a conservative approach, whereas injuries concomitant with fractures are treated surgically.[32] Posttraumatic arthritis, chronic ankle pain, disability, and instability are potential problems related to inadequate treatment and misdiagnosed or neglected syndesmotic injuries.[30,38,39]

Various fixation techniques have been used to stabilize syndesmotic injuries. Some of these are screw fixation, staples, polyester bands, bioabsorbable screws, syndesmosis hooks, Kirschner wires, and suture-button fixation.[34,37,38] Recently, the use of suture-button technique has become

[1]Ankara Education and Research Hospital, Orthopedics and Traumatology Department, Ankara, Turkey
[2]Department of Orthopedics and Traumatology, Dr. Nafiz Korez Sincan State Hospital, Ankara, Turkey
[3]Department of Orthopedics and Traumatology, Medical Park Hospital, Ankara, Turkey

Corresponding Author:
Onur Kocadal, MD, Ankara Education and Research Hospital, Orthopedics and Traumatology Department, Ayranci Mah. Tirebolu sok 5/10 Cankaya Ankara 06540 Turkey.
Email: onurkocadal@gmail.com

Table 1. Demographic Characteristics of Patients[a].

Patients	Age, y	Gender (Male:Female)	Side (Right:Left)	Fracture Type (L-B-T)
Screw fixation	44.8 ± 11.3 (16-65)	17:9	14:12	13:10:3
Suture-button fixation	43.3 ± 15.1 (16-61)	16:10	13:13	14:10:2
All patients	44.1 ± 13.2 (16-65)	33:19	27:25	27:20:5
P value	.6	.7	.7	.9

Abbreviations: B, bimalleolar fracture; L, lateral malleolus fracture; T, trimalleolar fracture.
[a]Values are expressed as mean ± standard deviation, with the range in parentheses.

increasingly popular because it allows dynamic fixation, physiological movement, early rehabilitation, satisfactory functional outcomes, and no requirement for implant removal.[13]

The most important clinical outcome is the accurate anatomic reduction of the syndesmotic injuries.[26] Computed tomography (CT) may be used to accurately define the assessment of postoperative malreduction.[14] CT imaging allows cross-sectional evaluation and volumetric analysis of the syndesmotic space,[16,30] which is a useful tool for the detection of minor syndesmotic diastasis. Thus, it provides more detailed and accurate information about the syndesmotic space.[7]

The malreduction rates have been reported to be 16% to 52% via screw fixation.[10,26,35] However, there is limited data regarding the reduction performance of suture-button fixation.[23] To our knowledge, there is no study in the literature evaluating the reduction performance of syndesmotic fixation techniques in terms of cross-sectional area and volumetric calculation of syndesmotic space.

The purpose of this study was to evaluate the reduction performance of screw fixation and suture-button techniques using images obtained from CT. The functional outcomes of both techniques were also compared.

Methods

The current study was approved by the local institutional review board, and the medical records of 64 patients treated in our regional trauma unit between January 2012 and March 2015 were evaluated retrospectively. These patients had been treated with screw fixation or suture-button fixation for syndesmotic injuries accompanying ankle fractures.

From the hospital records, data including patient demographics such as age, gender, and side treated were collected as well as postoperative complications, functional AOFAS scores, and radiologic reduction parameters in the patients who had postoperative CT imaging.

The presence of open fractures, neurovascular injury, and pathologic fractures were defined as exclusion criteria as well as age above 65 years. Those patients with a previous history of ankle surgery, space-occupying lesions, neuropathic arthropathy, and presence of ankle deformities in the affected or contralateral limb were also eliminated. A total of 12 patients were excluded from the study: 9 due to the lack of postoperative CT imaging, 2 on account of being older than 65 years, and 1 because of an open fracture. Thus, a total of 52 patients were included in the present study. The patients were divided into 2 groups (screw and suture-button) according to the fixation technique used.

The mean follow-up period was 16.7 ± 11.0 (range, 6-43) months and the mean age in the study population was 44.1 ± 13.2 (range, 16-65) years. Syndesmotic injuries were located on the right side in 27 patients and on the left side in 25. There was no difference in terms of gender and side between the groups. The demographic characteristics of all participants are presented in Table 1. Screw fixation was performed in 26 patients, and 26 had suture-button fixation (n = 26).

There were lateral malleolar fractures in 13 patients (50%) in the suture-button fixation and 14 patients (54%) in the screw fixation group. Ten of the patients (38%) in each group had bimalleolar fractures, whereas 3 patients (12%) in the suture-button fixation and 2 patients (8%) in the screw fixation group had trimalleolar fractures. There was no statistically significant difference in the fracture types between the groups ($P = .9$).

Operative Procedure

All the interventions were performed by 2 orthopedic trauma surgeons under regional anesthesia in the supine position. Lateral and/or medial and/or posterior malleolar fractures were fixed, if any. Following the fracture fixation, syndesmotic evaluation was performed using a fluoroscope-assisted external rotation stress test.[22] The presence of syndesmotic damage was diagnosed if the medial tibiotalar clear space was ≥5 mm under stress.[21] Syndesmotic reduction was achieved using a reduction clamp without direct visualization of the tibiofibular joint. Either a 3.5-mm cortical screw (AAP-Implantate AG, Berlin, Germany) or the suture-button fixation system (ZipTight Fixation System, Biomet Sports Medicine, Warsaw, IN) was used to repair the syndesmotic diastasis. The operative approach was decided according to personal preferences of the operating surgeon. Syndesmotic fixation materials were placed through a plate hole. All syndesmotic fixation materials were applied with fluoroscopic guidance in the posterolateral to anteromedial direction 2 cm proximal to the tibial plafond with dorsiflexion of the ankle. Screw fixation included 4 cortices.

In the suture-button fixation group, a 3.5-mm drill hole was used and a needle guide was passed through the tunnel. The oblong button, passing behind the needle guide, was placed onto the medial cortex of the tibia. Then the system was fitted to the lateral cortex of the fibula using the round button. Syndesmosis fixation was checked by fluoroscopy after the reduction forceps were removed.

Short leg splints were applied for 3 weeks on all patients. After splint removal, active and passive ankle joint movement was started and partial weight bearing was allowed. At the sixth postoperative week, full weight bearing was allowed. Syndesmotic screws were removed if local irritation was present.

Radiologic Evaluation

Radiologic evaluations were performed by postoperative CT scans that were obtained routinely within 2 days postoperatively. CT scans were made using the Optima CT540 scanner (General Electric, Milwaukee, WI) with a 1.0-mm slice thickness. The data obtained from the CT scans were transferred to OsiriX (version 5.9; Pixmeo, Geneva, Switzerland) software. Four parameters were taken into consideration for radiologic evaluation: anteroposterior reduction, rotational reduction, cross-sectional syndesmotic area, and distal tibiofibular volumes. All radiologic measurements were performed on the injured and contralateral limbs.

The method defined by Phisitkul et al was used to assess anteroposterior reduction.[24] Axial CT images 10 mm proximal to the tibiotalar joint were used for these measurements. A tangential line was drawn between the most lateral aspect of the anterior and posterior tubercles of the incisura fibularis of the tibia. Then a second line, perpendicular to the first, was drawn from the anterior tubercle of the tibia. The distance between the second line and the most anterior point of the fibula was measured (Figure 1).

Fibular rotation was assessed with the method defined by Dikos et al.[5] Fibular rotation measurements were performed 10 mm proximal to the tibiotalar joint. A tangential line was drawn between the anterior and posterior tubercles of the incisura fibularis of the tibia and a second line was drawn through the anterior and posterior fibular tubercles. The angle between the 2 lines was measured (Figure 2).

Axial CT images were used for the evaluation of the distal syndesmotic area. The syndesmotic area was created by connecting the anterior and posterior tubercles of the incisura fibularis and the anterior and posterior fibular tubercles through the nearest point (Figure 3).[8] Measurements were made at 3 different levels categorized as upper, middle, and lower at 1 cm intervals, parallel to and starting from the tibial plafond.

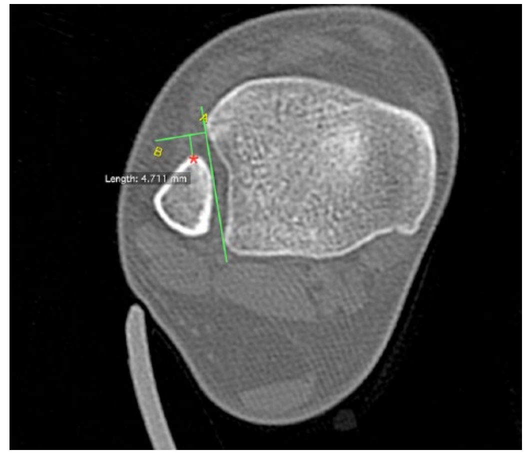

Figure 1. Measurement of anteroposterior reduction. Lines were drawn between the most lateral aspects of the tubercles of the incisura fibularis (Line A) and perpendicular to this from the anterior tubercle of the tibia (Line B). The distance between the line B and the most anterior point of the fibula (*) was measured.

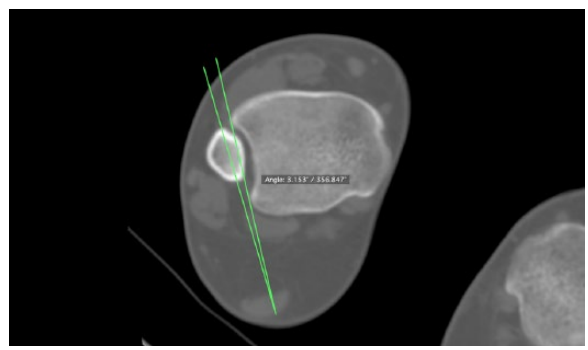

Figure 2. Fibular rotation measurement presented as the angle between the 2 lines, drawn between the tubercles of the incisura fibularis and through the anterior and posterior fibular tubercles.

The syndesmotic space regions were determined using 20 consecutive axial images starting from the tibial plafond proximally to 2 cm. Then volumetric analysis of the syndesmotic space was performed by 3-dimensional reconstruction (Figure 4).

Radiologic measurements were done by one of the authors. The second author also evaluated all the radiologic parameters to avoid any intraobserver errors. Repeat measurements were made by the same author 2 weeks after the first ones to evaluate intraobserver reliability. Intraclass coefficient correlations (ICCs) were used to assess reliability.

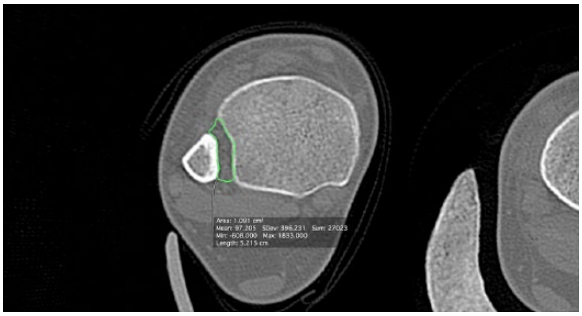

Figure 3. Evaluation of the distal syndesmotic area. The syndesmotic area was created by connecting the anterior and posterior tubercles of the incisura fibularis and the anterior and posterior fibular tubercles through the nearest point.

Functional Evaluation

Functional evaluation of patients was done using the American Orthopaedic Foot & Ankle Society (AOFAS) ankle hindfoot scale clinical rating system at the final follow-up.

Statistical Analysis

The statistical analysis was performed with the IBM SPSS Statistics 20 for Mac (Statistical Package for Social Sciences for Mac ver.20, IBM Corp, Armonk, NY). The distribution between the groups was found to be normal with the Kolmogorov-Smirnov test. The data were found to be homogeneously distributed with the Levene test. Thus, parametric tests were used for statistical analyses. Independent sample *t* tests and paired sample *t* tests were used to compare the data. A *P* value <.05 was considered statistically significant.

Results

There was no statistically significant difference in the radiologic parameters of healthy contralateral limbs between the groups (Table 2). In the screw fixation group, there were statistically significant differences in the measurements of fibular rotation ($P = .03$) and upper syndesmotic area ($P = .006$) compared to the contralateral limb. There were no significant differences in the other parameters ($P > .05$) (Table 3). In the suture-button fixation group, there were statistically significant differences in the measurements of the lower syndesmotic area ($P = .02$) and syndesmotic volume ($P = .04$) compared to the contralateral limb. There were no significant differences in the other parameters ($P > .05$) (Table 3).

The mean AOFAS score was 88.4 ± 9.2 in the suture-button fixation group, whereas it was 86.1 ± 14.0 in the screw fixation group ($P = .4$).

There was 1 patient with a low-grade infection in the suture-button fixation group. This patient was treated with an oral antibiotic. Implant removal was performed in another patient due to local implant irritation. There were 3 patients who developed transient tightness of the ankle during dorsiflexion in the early postoperative period. Spontaneous resolution of the symptoms occurred in these patients.

In the screw fixation group, implant removal was performed in 10 patients The mean implant removal period was 12.4 ± 5.1 (range 7-23) weeks. Screw breakage was seen in 1 patient. Another patient, who developed reflex sympathetic dystrophy, was treated conservatively.

The ICCs of intraobserver reliabilities (95% confidence interval [CI]) were 0.987, 0.925, 0.885, and 0.882 for the anteroposterior, rotational, cross-sectional area, and volumetric measurements. The ICCs of interobserver reliabilities (95% CI) were 0.962, 0.916, 0.867, and 0.861 for the anteroposterior, rotational, cross-sectional area, and volumetric measurements.

The post hoc power analysis was performed using the G*Power 3.1 statistical analysis program. The alpha error probability, effect size *d* value, and statistical power of the study (1-beta) were 0.05, 0.8, and 0.807, respectively.

Discussion

The current study evaluated how treatment with screw fixation influences rotational disturbance in syndesmosis injuries. Additionally, this study revealed that suture-button fixation technique has a tendency to increase the tibiofibular volume in syndesmotic injuries. Compared to contralateral limbs, there was an increase in the syndesmotic area at the ankle joint level with suture-button fixation and at 2 cm proximal to the ankle with screw fixation. However, the functional results revealed no difference between these fixation techniques.

Evaluation of a syndesmotic injury has traditionally been performed using static and/or stress anteroposterior and mortise radiographs.[29] Tibiofibular clear space, medial clear space, and tibiofibular overlap are the most frequently used radiologic parameters for the evaluation of syndesmotic structure integrity.[5,19] However, these techniques are poorly defined and have been shown to be unreliable.[5,10,20,29] CT is reported to be superior to conventional radiography in evaluating syndesmosis integrity.[5,17] Currently, the most reliable radiologic method for establishing the true alignment of ankle mortise is postoperative CT.[9] Bilateral CT investigations are suggested in the literature because of the possibility of individual or anatomic variations.[5,12,17,18,25,28] The current study demonstrated the utility of CT imaging in the evaluation of syndesmotic reduction. However, there has been no well-defined cut-off values for the radiologic parameters for a diagnosis of syndesmotic malreduction. Thus, routine CT

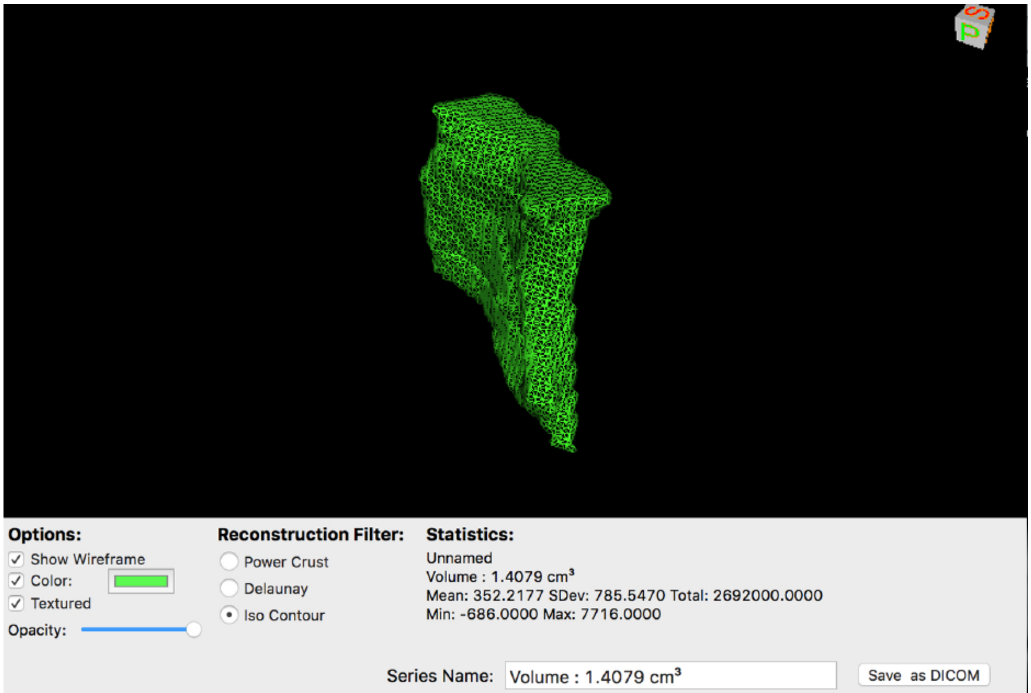

Figure 4. The volumetric analysis of the syndesmotic space.

Table 2. Radiological Comparison of Healthy Extremities[a].

Measurement	Screw Fixation	Suture-Button Fixation	All Patients	*P* value
Anteroposterior translation (mm)	1.77 ± 1.1 (0.3, 4.1)	1.86 ± 1.4 (–2.0, 5.0)	1.81 ± 1.2 (–2.0, 5.0)	.8
Fibular rotation (degree)	14.2 ± 7.9 (0.5, 28.8)	12.3 ± 5.6 (1.5, 26.2)	13.3 ± 6.8 (0.5, 28.8)	.3
Upper syndesmotic area (mm^2)	84.5 ± 28.5 (43.0, 142.8)	81.8 ± 27.3 (37.8, 168.3)	83.1 ± 27.4 (37.8, 168.3)	.7
Middle syndesmotic area (mm^2)	84.3 ± 19.8 (48.9, 129.0)	75.7 ± 21.2 (40.7, 128.1)	80.1 ± 20.5 (40.7, 129.0)	.1
Lower syndesmotic area (mm^2)	70.8 ± 23.6 (34.4, 137.3)	64.1 ± 12.0 (43.5, 92.3)	67.8 ± 18.8 (34.4, 137.3)	.2
Syndesmotic volume (mm^3)	1597.2 ± 363.7 (974.9, 2221.2)	1470.7 ± 339.1 (900.4, 2367.1)	1537.1 ± 350.9 (900.4, 2367.1)	.2

[a]Values are expressed as mean ± standard deviation, with the range in parentheses.

imaging should be offered after determination of well-defined cut-off values for the evaluation of syndesmotic reduction.

Coronal plane alignment is frequently taken into consideration when evaluating syndesmotic reduction. However, more diastasis occurs in the sagittal plane than the coronal during syndesmotic injuries.[1] There are studies in the literature illustrating how anteroposterior plane stabilization is better achieved via screw fixation than by suture-button fixation.[11] There are also papers indicating similar reduction performance on anteroposterior planes.[27] The lack of standardized measurement methods and/or imaging techniques might have resulted in these variations. Different measurement techniques have been described for sagittal plane displacement of the fibula.[4,8,24] Anteroposterior displacement of the fibula was best correlated with the Phisitkul's method in the literature.[6] Thus, Phisitkul's method was the chosen measurement technique for anteroposterior fibular translation in the current study.

One of the important issues in the treatment of syndesmotic injuries is the restoration of fibular rotation.

Table 3. Comparison of Radiological Parameters Between Healthy and Operated Extremities[a].

	Screw Fixation			Suture-Button Fixation		
Measurement	Operated Side	Healthy Side	*P* Value	Operated Side	Healthy Side	*P* Value
Anteroposterior translation (mm)	1.7 ± 2.0 (–4.0, 5.6)	1.7 ± 1.1 (0.3, 4.1)	.9	1.2 ± 1.2 (–2.1, 3.2)	1.86 ± 1.4 (–2.0, 5.0)	.06
Fibular rotation (degree)	10.9 ± 6.7 (0.3, 32.1)	14.2 ± 7.9 (0.5, 28.8)	.03*	14.4 ± 8.4 (1.2, 34.7)	12.3 ± 5.6 (1.5, 26.2)	.1
Upper syndesmotic area (mm^2)	99.0 ± 25.2 (55.7, 153.4)	84.5 ± 28.5 (43.0, 142.8)	.006*	88.9 ± 27.1 (45.4, 152.2)	81.8 ± 27.3 (37.8, 168.3)	.1
Middle syndesmotic area (mm^2)	86.2 ± 25.9 (46.1, 150.2)	84.3 ± 19.8 (48.9, 129.0)	.7	79.0 ± 23.3 (28.3,120.4)	75.7 ± 21.2 (40.7, 128.1)	.3
Lower syndesmotic area (mm^2)	71.5 ± 22.5 (35.6, 147,2)	70.8 ± 23.6 (34.4, 137.3)	.8	73.2 ± 18.2 (39.7, 101.3)	64.1 ± 12.0 (43.5, 92.3)	.02*
Syndesmotic volume (mm^3)	1677.2 ± 406.6 (1084.7, 2643.1)	1597.2 ± 363.7 (974.9, 2221.2)	.3	1589.2 ± 386.0 (913.5, 2370.5)	1470.7 ± 339.1 (900.4, 2367.1)	.04*

[a]Values are expressed as mean ± standard deviation, with the range in parentheses.

Thordarson et al reported the occurrence of supraphysiologic loading in the ankle joint in the case of a greater than 5 degree rotational malalignment.[31] In a prospective study conducted by Vasarhelyi et al, greater than 10 degrees of rotational asymmetry was demonstrated in 25% of the 61 patients treated with trans-syndesmotic screw fixation of the distal tibiofibular joint due to ankle fracture dislocations.[33] The current study also showed difficulty in maintaining fibular rotation in patients with screw fixation. To our knowledge, fibular rotation has not been evaluated with the suture-button fixation technique in the literature. Based on the study results, suture-button fixation maintained the fibular rotation within suitable limits.

Area measurements of the syndesmotic space were reported to be easy to perform, reliable, and a reproducible tool for syndesmotic diastasis.[16] Taser et al[30] and Malhotra et al[16] reported an increased cross-sectional area in the tibiofibular space in syndesmotic injuries. There was no significant difference in the cross-sectional area at 1 cm proximal to the ankle joint compared to the contralateral limb with screw fixation and suture-button fixation in the current study. However, there was a significant increase in diastasis compared with the contralateral limb at the ankle joint level with suture-button fixation and at 2 cm proximal to the ankle joint with screw fixation. There is no consensus in the literature indicating at which level evaluation of distal tibiofibular space is required. Thus, 3-dimensional volume investigation of syndesmotic space with multiplanar evaluation might be more appropriate than measuring the distal tibiofibular space at a single level.

Volumetric evaluation of syndesmotic space provides detailed information in cases of syndesmotic diastasis accompanying ankle injuries and for postoperative assessment of the integrity of the syndesmosis.[30] In a cadaveric study by Taser et al, they presented a 43% increase in syndesmosis volume due to 1 mm syndesmosis diastasis.[30] To our knowledge, syndesmotic space volume has not been evaluated in patients after surgery due to syndesmotic injuries. Compared with the contralateral limb, there were increased syndesmotic space volumes in both screw fixation and suture-button fixation. This increase in volume was statistically significant only in suture-button fixation. However, the current study design did not allow the consequences of volumetric alterations on functional scores to be determined.

Syndesmosis malreduction was reported for 16% to 52% of cases after screw fixation.[10,26,35] There are limited studies comparing the reduction outcomes of screw fixation and suture-button fixation from a radiologic point of view. In their prospective radiologic study, Kortekangas et al did not find a difference in malreduction rates with screw fixation and suture-button fixation techniques.[12] In their cadaveric study comparing both techniques, Westerman et al demonstrated the association of suture-button fixation with a more anatomic post-fixation position compared to screw fixation especially in the sagittal plane.[36] However, both of these studies were focused on syndesmotic injuries using coronal and sagittal plane evaluations. In the present study, cross-sectional areas and volumetric analyses were also interpolated to coronal and sagittal plane measurements.

In the literature, no superiority of functional outcomes between screw fixation and suture-button techniques has been reported,[2,12] which is similar to our findings. The reduction performance of the suture-button and screw fixation techniques was delineated in the current study. However, severity of trauma, presence of cartilage injury and/or the cartilaginous and soft tissue healing process consequent to the trauma could affect ankle joint function. Thus, it is more appropriate to evaluate syndesmotic injuries based on radiologic parameters rather than functional scoring. Moreover, it seems that instead of single plane imaging, in which parameters such as tibiofibular clear space, medial clear space and tibiofibular overlapping are investigated, it would be preferable to evaluate the reduction degree of syndesmotic injuries using a multiplanar method.

This study has several limitations, one of which is the retrospective nature of the study. The syndesmosis complex is composed of anterior tibiofibular, transverse tibiofibular, intraosseous tibiofibular, and posterior tibiofibular ligaments.[25] Syndesmosis geometry might be changed depending on the affected parts and severity of injury. The lack of standardization of the injured part of the syndesmosis and severity of injury in the study population is one of the limitations. Another limiting factor is that the distal fibular anatomic variations in the study patients were neglected. However, comparisons of the affected limb with the contralateral side were thought to lessen the possible negative effects on fixation outcomes. In the current study, CT evaluations were performed in the early postoperative period, which is not a suitable time for the detection of late diastasis and/or implant-related problems such as creep phenomenon. Thus, the lack of long-term CT evaluations to investigate reduction accuracy might be another limiting factor. In the current study, suture-button and screw fixation techniques were compared based on functional outcomes without any radiologic comparison. The study design, which provided a comparison of radiologic parameters between the affected and contralateral healthy side with each operative approach hinders the comparison of these different techniques. Also, the study design was not suitable for evaluation of the degree of malreduction and functional outcomes.

Conclusion

CT imaging was a useful method for the evaluation of postoperative syndesmotic reduction. The current study found that although the functional outcomes of both techniques were similar, the restoration of fibular rotation after syndesmotic injuries via screw fixation was a potential problem.

Furthermore, syndesmotic space might be increased with the suture-button fixation technique. Potential problems of each fixation technique should be considered during surgery. Multiplanar radiologic evaluations of the syndesmotic space should be taken into consideration when determining the quality of syndesmotic reduction.

Declaration of Conflicting Interests

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