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## Distal Tibiofibular Syndesmosis Dysfunction: A Systematic Literature Review of Dynamic Versus Static Fixation Over the Last 10 Years

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## ABSTRACT

The goal of the present work was to perform a systematic review of the literature of the past 10 years regarding dynamic and static fixation of the distal tibiofibular syndesmosis to determine any clinical differences between the 2 procedures. A literature search of the PubMed MEDLINE database was conducted to identify relevant studies related to distal tibiofibular syndesmosis. Studies before January 1, 2007, were excluded to limit the project to the recent literature. Clinical outcomes, device removal rates, time to weightbearing after the initial procedure, and the cost effectiveness of each device were explored. In these 26 studies, 350 patients were treated using a dynamic technique and 845 were treated using a static technique. The weighted American Orthopedic Foot and Ankle Score was 91.70 (standard error [SE] 1.87) for dynamic fixation patients and the weighted average was 86.48 (SE 2.17) for static fixation patients ( $p = .068$ ). A secondary procedure to remove the fixation device was performed in 7.7% of dynamic fixation patients and in 39.4% of static fixation patients when studies with 100% device removal were excluded ( $p < .0001$ ). The mean time to weightbearing was 5.96 (SE 0.72) weeks for patients who underwent dynamic fixation and 10.45 (SE 0.99) weeks for those who had static fixation ( $p = .0002$ ). The cost for dynamic fixation was found to be less than that for static fixation when secondary procedures for device removal were considered. Based on similar clinical functional scores, lower secondary procedure rates, faster time to full weightbearing, and lower costs to patients, dynamic fixation of the distal tibiofibular syndesmosis may be a superior option compared with static fixation.

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The bony ankle joint consists of the tibia and fibula articulating with the talus. The ligamentous stability of the joint depends proximally on the tibiofibular syndesmosis; laterally on the anterior talofibular ligament, calcaneofibular ligament, and posterior talofibular ligament; medially on the deltoid ligament; and circumferentially on the joint capsule. A syndesmosis is defined as a fibrous joint formed by 2 adjacent bones linked by membranes or ligaments. The tibiofibular syndesmosis is made of 4 ligamentous structures: the anterior tibiofibular ligament, the posterior tibiofibular ligament, the transverse ligament, and the interosseous membrane.

The wide, trapezoid-shaped anterior tibiofibular ligament is located superior to the anterior mortise of the ankle joint and runs posteroinferiorly from the tibia to the fibula. The posterior

tibiofibular ligament is similarly shaped and is located superior to the posterior mortise. It runs anteroinferiorly from the tibia to the fibula. The transverse ligament is located posteriorly and is a round, thick ligament that runs horizontally from tibia to fibula. The interosseous membrane spans from the tibia and fibula and runs most of the length of the 2 bones, eventually blending into the anterior and posterior tibiofibular ligaments. It is strong but not completely rigid, offering a small degree of motion and an elastic spring force during ambulation. When the ankle is fully dorsiflexed, the syndesmosis is placed in tension. Adding an external rotation force places this joint at greatest risk of rupture.

### Pathophysiology of Syndesmotom Injury

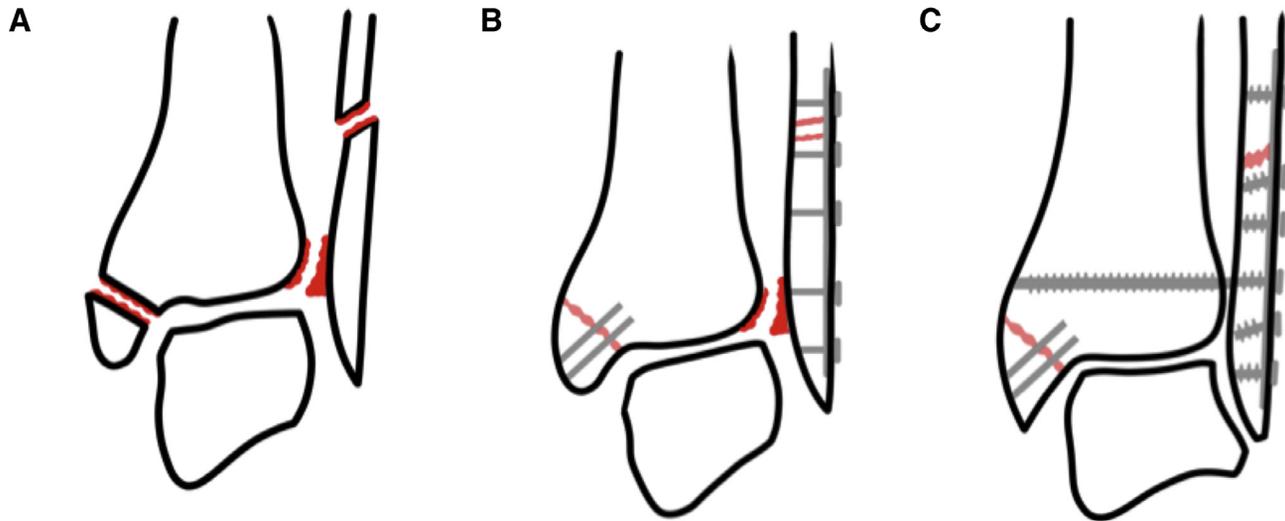
Injury to the ankle syndesmosis is most commonly caused by a lateral force applied to an ankle that is dorsiflexed. A lateral force, causing the talus to press against the distal fibula, is distributed and applies tension to the syndesmosis. This tension causes a sequence

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**Fig. 1.** Static fixation of syndesmotic injury via trans-syndesmotic screw (A). Weber type C injury with syndesmotic involvement. (B) Standard reduction and fixation of Weber type C injury without fixation of ankle syndesmosis. (C) Static fixation of syndesmotic injury with a trans-syndesmotic metallic screw.

of injuries that depends on the degree of force being applied. Tearing of the anterior tibiofibular ligament is the first injury, followed by injury to the interosseous membrane. If the force is great enough, the posterior tibiofibular is the next to rupture, followed by medial injury to the deltoid ligament. Sometimes a spiral fracture of the proximal fibula, known as a Maisonneuve fracture, can occur.

Distal tibiofibular syndesmosis instability has been estimated to occur in 5% to 23% of ankle fractures (1–4). There are estimated to be 6445 syndesmotic injuries in the United States every year (5). The most common mechanisms leading to injury of the distal tibiofibular syndesmosis are external rotation and hyperdorsiflexion, whereas eversion, inversion, plantar flexion, pronation, and internal rotation are less common mechanisms (6). Injuries to the syndesmosis produced by these mechanisms commonly occur in high-impact sports activities, such as football, skiing, or low-impact incidents such as slipping on ice or falling down stairs (7). Often these injuries lead to Weber B, Weber C, and Maisonneuve fractures, which are the most common types of ankle fractures leading to syndesmotic instability (7,8). The rate of syndesmosis injury has been found as high as 39% to 45% in Weber B ankle fractures (9,10).

#### *Anatomic Reduction and Fixation of the Ankle Syndesmosis*

Early fixation of the unstable syndesmosis is necessary to prevent long-term effects, such as degenerative arthritis. To avoid posttraumatic arthritis, the first step in fixation of a syndesmotic injury is to reduce the fibula in the fibular notch using a reduction clamp. The aim of both static and dynamic fixation is to restore the normal anatomy of the ankle syndesmosis and not to directly repair the syndesmotic ligaments. Correct positioning of the distal tibia to the fibula after traumatic injury allows the ligaments of the syndesmosis to heal in the proper anatomic position.

The gold standard of care for syndesmotic injury after ankle fracture has been static fixation via a trans-syndesmotic screw (Fig. 1). The screw, or screws, can be metallic or bioabsorbable and can be different lengths, diameters, and placed in different positions (11). In addition to screws, another technique for static syndesmotic fixation is a bolt-hook method, which does not require removal of the hardware before walking (12).

In static fixation, the screw is placed parallel to the tibiotalar joint to prevent shifting of the fibula. It is commonly placed 2 to 4 cm above the tibial plafond, and at a 30° anteromedial angle. Because the natural anatomic position of the fibula is posterior relative to the tibia, this angle allows proper fixation of the fibula in the tibiofibular notch. Also during static fixation, it is common to place the syndesmotic screw with the foot in dorsiflexion. This step is because taken the anterior talus widens the ankle mortise in dorsiflexion. Placing the screw while the ankle is in neutral or plantar flexion impairs this widening during dorsiflexion.

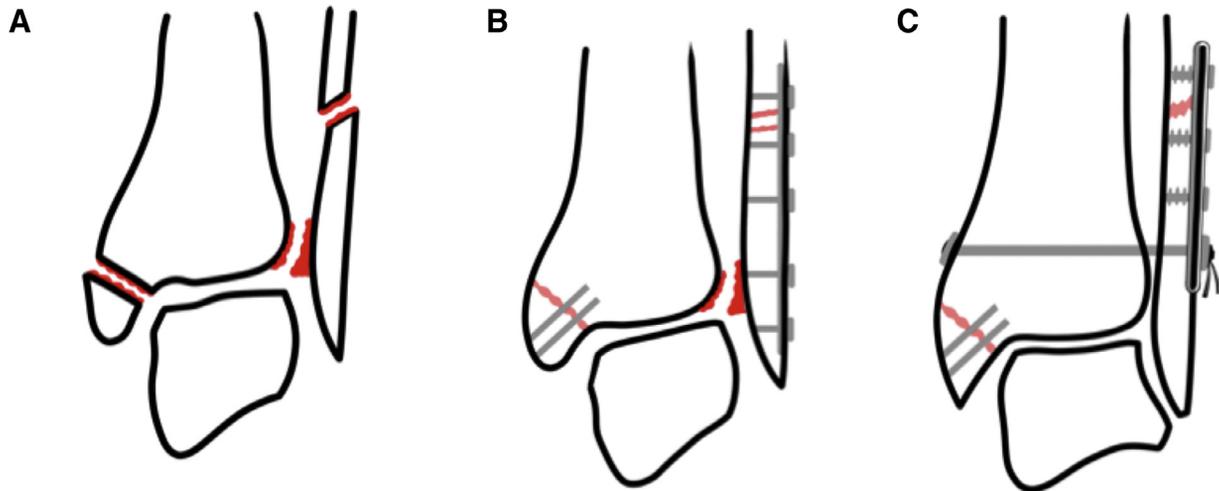
A dynamic suture-button technique has in recent years been used in lieu of the trans-syndesmotic screw to stabilize syndesmotic injuries (Fig. 2). This technique involves the fixation of the distal tibiofibular syndesmosis using a trans-syndesmotic fiber wire secured using knotless sutures, often in a fibular plate (13,14). The main advantage to dynamic fixation of the ankle syndesmosis is that this technique allows for physiologic movement between the tibia and fibula while maintaining the required reduction. This lack of a static fixation device also theoretically removes the need for implant removal, which is a major drawback to static fixation.

This review aims to identify studies in which a static technique, a dynamic technique, or both were used to fix the distal tibiofibular syndesmosis and to compare outcomes between the 2 techniques. This comparison has not been thoroughly investigated in the literature. The primary comparisons made between the 2 fixation techniques are functional outcome scores and additional surgery rates for device removal. Functional outcomes scores compared were the American Orthopedic Foot and Ankle Score (AOFAS) or the Olerud-Molander Ankle Score (OMAS) (15,16). Secondary comparisons between the 2 fixation techniques included pain/irritation rates, infection rates, revision rates, malreduction rates, and mean time to weightbearing.

#### **Materials and Methods**

A Pubmed MEDLINE literature search was conducted to identify study articles in which distal tibiofibular syndesmosis dysfunction was stabilized via static and/or dynamic fixation. The following search terms were used to identify relevant studies: syndesmo\* AND (screw OR static OR suture-button OR suture button OR mitek OR arthrex OR tightrope OR tight rope OR dynamic). Inclusion criteria for the articles included the following:

- Fixation of the distal tibiofibular syndesmosis in the study articles must have been completed by using a static technique, which includes screws, both metal



**Fig. 2.** Dynamic fixation of syndesmosis injury via suture-button. (A) Weber type C injury with syndesmosis involvement. (B) Standard reduction and fixation of Weber type C injury without fixation of the ankle syndesmosis. (C) Dynamic fixation of the ankle syndesmosis using a trans-syndesmosis fiber wire secured using knotless sutures.

and bioabsorbable, and bolts, and/or by a dynamic technique, the suture-button construct.

- An AOFAS or OMAS must have been recorded.
- Surgical hardware removal rates must have been recorded.

**Article Search**

The initial PubMed MEDLINE online database literature search identified 393 articles. Screening of all articles led to 44 articles being selected for full-text review. Articles excluded were those published before January 1, 2007, non-English articles, articles unrelated to syndesmosis fixation, cadaver studies, and systemic review articles. These 44 articles were either dynamic fixation only studies, static fixation only studies, or dynamic versus static fixation studies. These 44 articles were screened to determine if primary outcome data (functional outcome score and rates of secondary surgery for device removal) were included. If these 2 primary data were not recorded, the study article was excluded (Fig. 3).

**Statistical Methods**

Random effects models were used to integrate the estimates from different studies. For functional score, follow-up time, and time to weightbearing, the effect size was defined as mean or mean difference, whatever appropriate. Proportions were first logit transformed (log odds) for the model fitting and then transformed back to proportions. When range was reported, the Chebyshev rule was applied to estimate the standard deviation if it was not reported in the study (ie, approximated standard deviation = range/6) (17). All statistical tests were 2-sided Wald  $\chi^2$  tests; *p* values of < .05 were considered to be statistically significant. All statistical analyses were performed using R 3.3.1 (The R Project, Vienna, Austria).

Because the studies reviewed did not have uniform study populations (ie, populations may be static patients only, dynamic patients only, or a combination of the 2),

statistics performed are meant to be more suggestive and informative rather than appropriate for a meta-analysis. Furthermore, the majority of sources of the data were retrospective studies, which would not be appropriate sources for a meta-analysis. This article focuses on a systematic review of this topic over the past 10 years while providing suggestive statistics. In the future, if there are enough randomized, controlled-trial papers published, it would be more accurate to perform a systematic review and meta-analysis simultaneously.

**Results**

The study outcomes of the 25 relevant articles found are described below in Tables 1–5. The primary data of functional scores, AOFAS or OMAS, and removal rates are recorded in these tables. Table 1 describes the primary outcomes in 6 dynamic fixation only studies. Table 2 describes the primary outcomes in 12 static fixation only studies. Table 3 describes the primary outcomes in 7 dynamic and static comparison studies. Table 4 describes the secondary outcomes of all dynamic fixation patients. Table 5 describes the secondary outcomes of all static fixation patients. Secondary data comparisons are shown in Tables 4 and 5.

The weighted average of AOFAS scores for 271 dynamic patients from 10 studies was 91.70 (standard error [SE] 1.87) at an average follow-up of 21.77 (SE 2.52) months. The weighted average of AOFAS scores for 494 static patients from 11 studies was 86.48 (SE 2.17) at an average follow-up of 38.72 (SE 8.72) months. The differences in these weighted AOFAS scores was not statistically significant (*p* = .068). The

**Table 1**  
Dynamic fixation only studies

Authors	Year	Study Type	Device Used	Functional Score	No. of Patients	No. of Patients With Device Removal	Functional Score, Mean ± SD (range)	Mean Follow-Up (range), Months
Degroot et al (18)	2011	Prospective	Arthrex TightRope	AOFAS	24	6	94.17 (71 to 100)	20 (5 to 38)
Qamar et al (19)	2011	Retrospective	Arthrex TightRope	AOFAS	16	1	86 (48 to 100)	26 (24 to 38)
Naqvi et al (20)	2012	Retrospective	Arthrex TightRope	AOFAS	49	3	85.57 ± 16.71	24 (12 to 38)
Rigby et al (21)	2013	Retrospective	Arthrex TightRope	AOFAS	37	4	97 (90 to 100)	23.6 ± 4.3
Bondi et al (22)	2016	Prospective	Arthrex TightRope	AOFAS	36	1	93.11 ± 4.38	28.64 (6 to 60)
Anand et al (23)	2017	Retrospective	Arthrex TightRope	AOFAS	36	1	88.8 (67 to 98)	14 (12 to 26)
Totals					198	16 (8.1%)		

Abbreviations: AOFAS, American Orthopedic Foot and Ankle Score; SD, standard deviation.

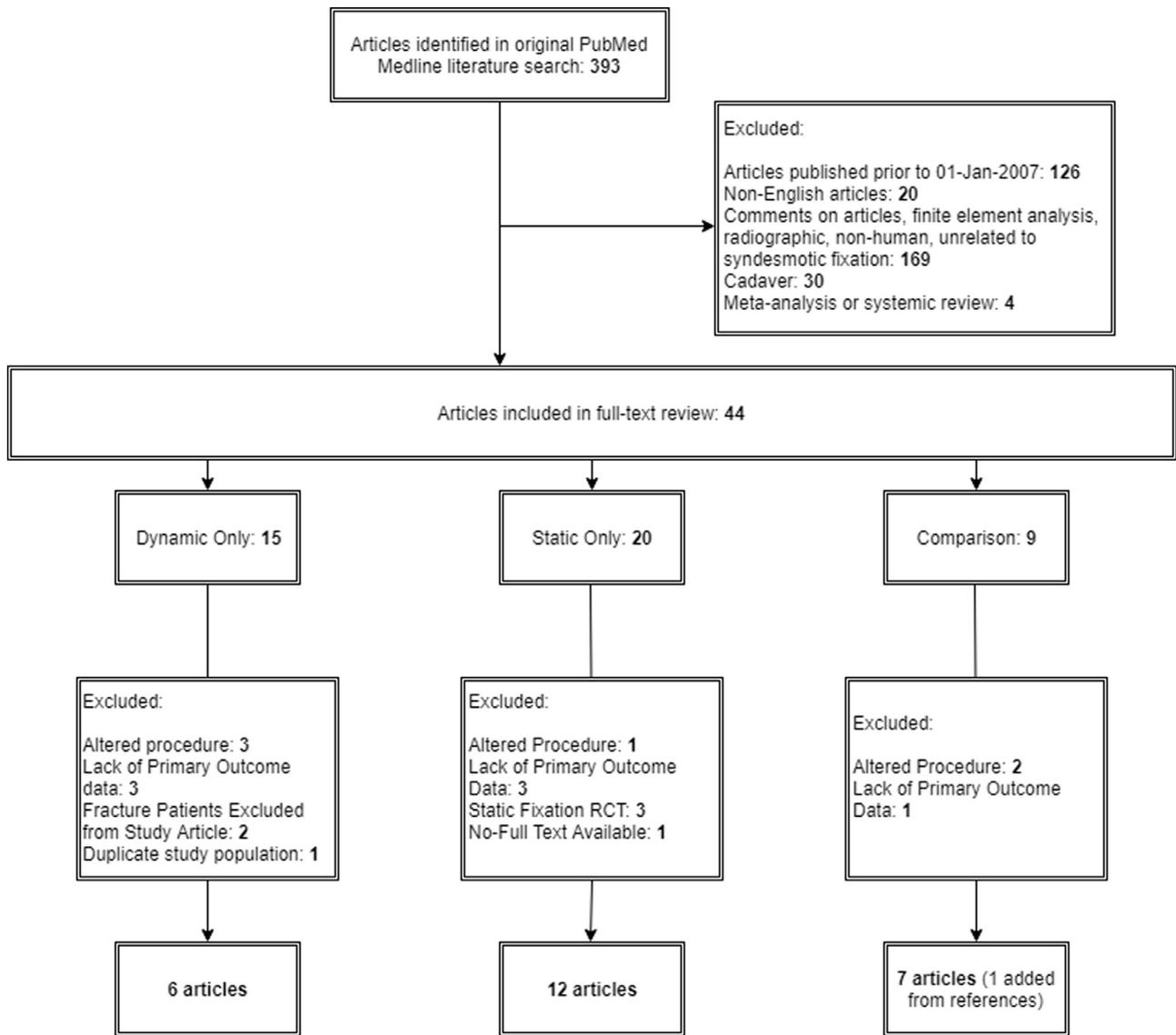


Fig. 3. Flowchart for the methodology of paper selection.

**Table 2**  
Static fixation-only studies

Authors	Year	Study Type	Device Used	Functional Score	No. of Patients	No. of Patients With Device Removal	Functional Score Mean ± SD (range)	Mean Follow-Up (Ranges), Months
Ahmad et al (24)	2009	Retrospective	Bioabsorbable screws	AOFAS	70	2	90 (44 to 100)	32.5
De Vil et al (12)	2009	Retrospective	Bolt	AOFAS	28	5	88 (33 to 100)	66
Hamid et al (25)	2009	Retrospective	Metallic screw	AOFAS	52	15	85.2 (55 to 100)	30
Egol et al (4)	2010	Retrospective	Metallic screw	AOFAS	79	19	83	12
Miller et al (26)	2011	Prospective	Metallic screw	OMAS	25	25	75	13
Mohammed et al (27)	2011	Retrospective	Metallic screw	OMAS	12	12	75	13 (7 to 21)
Tucker et al (28)	2013	Retrospective	Metallic screw	OMAS	63	43	77.06	31 (10 to 43)
Schepers et al (29)	2014	Retrospective	Metallic screw	AOFAS	93	81	92	54 ± 24
				OMAS			77	
Kaftandziev et al (30)	2015	Retrospective	Metallic screw	AOFAS	82	23	85.2 (55 to 100)	
Kwaadu et al (31)	2015	Retrospective	Lagged metallic screw	AOFAS	31	31	88.38 (42 to 100)	34.87 (18-52)
Veen et al (32)	2015	Retrospective	Metallic screw	AOFAS	26	26	86.7 ± 19.5	55.8 ± 13.2
				OMAS			81.9 ± 15.7	
Steinmetz et al (33)	2016	Retrospective	Metallic screw	AOFAS	126	126	93 ± 9 (49 to 100)	70.8 (34.8 to 126)
				OMAS			93 ± 10 (45 to 100)	
Totals					687	408 (59.4%)		

Abbreviations: AOFAS, American Orthopedic Foot and Ankle Score; OMAS, Olerud-Molander Ankle Score; SD, standard deviation.

**Table 3**  
Dynamic versus static fixation

Authors	Year	Study Type	Device Used	Functional Outcome Score	Dynamic—No. of Patients	Dynamic—No. of Devices Removed	Dynamic—Functional Score Mean (range)	Static—No. of Patients	Static—No. of Devices Removed	Static—Functional Score Mean (range)	Mean Follow-Up Time (months)
Coetzee et al (34)	2009	RCT	TightRope and screw	AOFAS	12	1	85.2 (65 to 100)	12	1	75.5 (61 to 100)	12
Cottom et al (35)	2009	RCT	TightRope and screw	AOFAS (modified)	25	0	50.64 (30 to 63)	25	17	53.45 (25 to 63)	D: 10.8 S: 8.2
Kortekangas et al (36)	2015	RCT	TightRope and screw	OMAS	21	1	82	22	3	84	24
Lafamme et al (37)	2015	RCT	TightRope and screw	OMAS	33	2	93.3 ± 10.2 (65 to 100)	32	11	87.7 ± 12.2 (65 to 100)	12
Seyhan et al (38)	2015	Retrospective	TightRope and Screw	AOFAS	15	6	93.73 ± 7.38	17	17	93.35 ± 6.93	12
Kim et al (39)	2016	Retrospective	TightRope and Screw	AOFAS	20	0	88.1 (79 to 95)	24	24	86.6 (75 to 96)	D: 13.4 S: 14.6
Kocadal et al (40)	2016	Retrospective	ZipTight and Screw	AOFAS	26	1	88.4 ± 9.2	26	10	86.1 ± 14	16.7 ± 11 (6 to 43)
Totals					152	11 (7.2%)		158	83 (54.6%)		

Abbreviations: AOFAS, American Orthopedic Foot and Ankle Score; D, dynamic; OMAS, Olerud-Molander Ankle Score, RCT, randomized controlled trial; S, static.

difference in follow-up times was also not statistically significant ( $p = .06$ ).

Studies that recorded an AOFAS or OMAS, but no standard deviation or range, were excluded from these weighted averages (4,26–29,36). As a result, there was no weighted average for OMAS scores. The study performed by Cottom et al (35) in 2009 used a modified AOFAS scoring scale and was not included in the AOFAS weighted average.

Of the 845 total static procedure patients, 491 (58.1%; range 2.9% to 100%) of them had a secondary procedure to remove their hardware. If the studies in which all screws were removed routinely are not considered, 230 of 584 (39.4%; range 2.9% to 87.1%) of the static procedure patients underwent a secondary procedure to remove their screws. Secondary removal surgery to remove dynamic devices was done in 27 of 350 (7.7%) patients. When the 39.4% device removal rate in the 584 static patients was compared with the 7.7% device removal rate in 350 dynamic patients, the difference was statistically significant ( $p < .0001$ ).

The weighted average time to weightbearing for 212 dynamic procedure patients from 7 studies was found to be 5.96 (SE 0.72) weeks. The weighted average time to weightbearing for 151 static procedure patients from 2 studies was 10.45 (SE 0.99) weeks. The differences in weighted average time to weightbearing was statistically significant ( $p = .0002$ ). The study performed by Kocadal et al (40) recorded time to weightbearing; however, a standard deviation or range was not recorded and therefore could not be included in the weighted averages. Pain/irritation rates ( $p = .94$ ), infection rates ( $p = .28$ ), revision rates ( $p = .64$ ) and malreduction rates ( $p = .38$ ) were not significantly different between dynamic and static procedure patients.

### Discussion

Syndesmotic instability often occurs concurrently with ankle fractures and until recently has been treated solely with a trans-syndesmotic screw. However, the dynamic suture-button technique has become more commonplace owing to possible advantages when compared with the typical trans-syndesmotic screw. This review demonstrated better clinical outcomes for patients with dynamic fixation when compared with patients who had static fixation; however, the difference was not statistically significant. Time to weightbearing was found to be significantly shorter for patients who has a dynamic procedure when compared with those who had a static procedure; however, this finding may be of limited value. Time to weightbearing was recorded in only 2 static procedure studies reviewed. Time to weightbearing for static procedure patients is often recommended to be 6 to 8 weeks, which is near the average time to weightbearing found for patients who underwent a dynamic procedure. However, weightbearing often cannot begin in patients who had a static procedure until screw removal is performed, which is not required before weightbearing with a dynamic suture button. Complication rates were found to be similar between the procedures. Suture-button devices were found to have significantly lower rates of secondary procedures to remove the device when compared with static procedures.

Suture-button devices are designed to forgo the need for a secondary procedure for device removal and allow for physiologic motion at the syndesmosis, which differs from static fixation because screws have been shown to eliminate physiologic motion in cadaveric studies (41–43). Suture-button devices have been shown to produce an increase in AOFAS scores more quickly than screws at the 3-month follow-up; however, there was no significant difference at the 6- or 12-month follow-up visits (37). The same study found a quicker return to work for patients with a suture button, although the difference was not found to be significantly different. In another study, the mean time to weightbearing was 4.1 weeks for patients with a suture button and 6.3 weeks in

**Table 4**  
Dynamic secondary outcomes

Authors	Year	No. of Patients	Irritation/Pain	Infection	Revisions	Malreduction	Average Time to Weightbearing (range), Weeks
Cottom et al (41)	2008	25	0	0	0	0	5.52 ± 1.93 (2 to 8)
Degroot et al (18)	2011	24	5	0	0	0	5.7 ± 2.1 (2 to 10)
Qamar et al (19)	2011	16	6	2	0	0	4.5 (4 to 6)
Naqvi et al (20)	2012	49	1	2	0	0	7.7 ± 1.1 (5 to 10)
Rigby et al (21)	2013	37	7	3	2	0	4.47 ± 1.81
Bondi et al (22)	2016	36	1	0	0	0	NR
Anand et al (23)	2017	36	1	0	1	1	7.3 (6 to 10)
Coetzee et al (34)	2009	12	1	1	0	0	NR
Cottom et al (25)	2009	25	0	0	0	0	5.52 (2 to 8)
Kortekangas et al (36)	2015	21	0	1	1	1	NR
Laflamme et al (37)	2015	33	0	2	0	0	NR
Seyhan et al (38)	2015	15	6	0	0	0	NR
Kim et al (39)	2016	20	0	0	0	0	NR
Kocadal et al (40)	2016	26	0	1	0	0	6
Totals		375	28 (7.4%)	12 (3.2%)	4 (1.1%)	2 (0.5%)	

Abbreviation: NR, not reported.

patients with a screw; return to work was found to be 2.8 months for the suture-button group and 4.6 months for the screw group (44). Plantar and dorsiflexion have been found to be significantly better in patients with a suture button when compared with patients with a screw at the 6- and 12-month follow-ups (38).

Suture-button devices have been found to be a risk for medial neurovascular bundle entrapment and deep infections after erosion by the fiber wire (45,46). Osteomyelitis has been reported as a complication along with intraosseous migration of the lateral endobutton and medial endobutton malpositioning (47,48). Other complications seen with the suture-button device are subsidence of bone by the fiber wire and knot irritation (18,19,21).

Screws often require a secondary operation for routine device removal; however, there is no consensus on whether or not device removal is necessary. Two separate studies have different conclusions with regard to screw removal, with one recommending screw removal (49) and the other recommending not removing the screw after the

initial procedure (50). A literature review performed in 2016 does not support the routine removal of screws; however, the authors stated that the literature is not of sufficient quality to make a definitive conclusion (51). Screw removal has been found to not affect clinical outcomes at the 1-year follow-up after removal at 3 months postoperatively compared with retained screws (52). Clinical outcomes have been found to not be affected by screw removal in other studies, which strengthens the case to not routinely remove screws (25,26,30,52,53).

Adding to the debate surrounding removal versus retention of the initial screw are associated complications with the additional procedure, including superficial and deep infections and recurrent syndesmotom diastasis (54,55). Screws have also been found to break and loosen after the initial procedure (56).

Study articles used in this review reported similar rates of irritation or pain from both the suture-button device and screw, along with similar rates of infections. Malreduction and revision surgeries were uncommon in both groups.

**Table 5**  
Static secondary outcomes

Authors	Year	No. of Patients	Irritation/Pain	Infections	Revisions	Malreduction	Average Time to Weightbearing (weeks)
Ahmad et al (24)	2009	70	6	0	0	0	NR
De Vil et al (12)	2009	28	7	0	0	2	NR
Hamid et al (25)	2009	52	2	0	0	0	NR
Egol et al (4)	2010	79	0	4	2	0	NR
Miller et al (26)	2011	25	0	0	0	0	NR
Mohammed et al (27)	2011	12	0	0	1	0	NR
Tucker et al (28)	2013	63	3	0	0	0	NR
Schepers et al (29)	2014	93	1	6	0	0	NR
Kwaadu et al (31)	2015	31	10	1	2	0	NR
Veen et al (32)	2015	26	0	0	0	0	NR
Steinmetz et al (33)	2016	126	14	5	0	3	7 ± 7 (range 2 to 45)
Coetzee et al (34)	2009	12	1	0	0	0	NR
Cottom et al (25)	2009	25	0	0	0	0	10.52 (range 8 to 14)
Kortekangas et al (36)	2015	22	3	0	0	3	NR
Laflamme et al (37)	2015	32	11	0	1	4	NR
Seyhan et al (38)	2015	17	4	0	0	0	NR
Kim et al (39)	2016	24	0	0	0	0	NR
Kocadal et al (40)	2016	26	0	0	0	0	6
Totals		763	62 (8.1%)	16 (2.1%)	6 (0.8%)	12 (1.6%)	

Abbreviation: NR, not reported.

Biomechanical and cadaver studies have been done exploring the suture-button constructs and screws. Both devices were shown to reduce the syndesmosis comparable with the nonoperated side and comparable to each other in the overall reduction of the syndesmosis (57). Restoration of physiologic motion by the suture-button device has been shown not to occur (58); however, fibular translation in the sagittal direction has been found to be significant in suture-button devices when compared with screws, which could affect syndesmotic healing (59).

Difference in cost effectiveness for the patients of the traditional trans-syndesmotic screw method versus the suture-button method has been explored (60). Neary et al (60) found with a hardware removal rate of 10% for suture-button devices and 20% for screws, the suture button was more cost effective than the traditional trans-syndesmotic screw. This review found the suture-button removal rate to be lower and the screw removal rate to be higher than the rates used in this cost-effectiveness study. Furthermore, current literature from Up-To-Date recommends 100% removal of screws before full weightbearing (62). If 100% of screws were to be removed, the cost of 2 procedures would be higher than the one intended for suture-button devices, which was shown in the cost-effectiveness study with lower removal rates. In addition to cost to patients, operating room costs have been examined for secondary hardware removal (61). The average cost per hardware removal procedure was found to be \$3759, with an average operating room usage time of 67.9 minutes. In a separate study used in this review, the average cost of metalwork removal was found to be £1372 (\$1768) (28).

This review found dynamic and static procedures for fixation of the distal tibiofibular syndesmosis to have similar clinical outcomes and complication rates. The difference in clinical outcomes, although not statistically significant, may hold clinical significance. Lower rates of secondary procedures for device removal, faster time to weightbearing, and lower cost to patients and clinics were found for dynamic suture-button devices. Because of these findings, it may be more beneficial to patients and providers to use the dynamic suture-button devices instead of the traditional static screw fixation, or similar static devices, for syndesmotic fixation.

### Limitations

Limitations of this review include the lack of randomized controlled studies comparing static fixation versus dynamic fixation of the distal tibiofibular syndesmosis and relatively small sample size from each of the patient populations. More randomized, controlled trials will need to be performed to obtain more powerful data and to maintain uniformity in outcome data recording. Functional outcome scores were often not recorded uniformly across studies, because some studies did not record standard deviations or ranges, and this affected data analysis. Larger sample sizes are needed to decrease variability, which may be seen owing to differences in outcome recording between study articles. In conclusion, based on this review we believe that future reviews should aim to improve in these areas specifically.

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