Current Concepts Review

Injuries to the Ankle Syndesmosis

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- ➤ Despite being common, syndesmotic injuries are challenging to diagnose and treat.
- ➤ Anatomic reduction of the ankle syndesmosis is critical for good clinical outcomes.
- ➤ Intraoperative three-dimensional radiography and direct syndesmotic visualization can improve rates of anatomic reduction.
- ➤ The so-called gold-standard syndesmotic screw fixation is being brought increasingly into question as new fixation techniques emerge.
- ➤ Syndesmotic screw removal remains controversial, but may allow spontaneous correction of malreductions.

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Ankle injuries are commonly seen by orthopaedic surgeons for definitive treatment. Approximately 5% to 10% of all ankle sprains[1,2] and 23% of all ankle fractures[3] involve trauma to the distal tibiofibular syndesmosis. The coexistence of osseous or deltoid ligament injuries can critically destabilize the ankle.

Despite the common occurrence of ankle injuries, a recent survey of orthopaedic and trauma surgeons found disagreement with regard to the treatment of syndesmotic injuries[4]. The surgeons reported achieving reduction through several different methods, including manual reduction, or use of reduction forceps, lag screws, or Kirschner wires. Similarly, indications for syndesmotic screw removal include limited ankle motion and the risk of screw breakage. Discrepancies also exist with regard to the number of screws used, number of cortices engaged, level of placement of the syndesmotic screws, time to weight-bearing following surgery, type of anesthesia used during removal, and timing of screw removal.

With such variation and disagreement in treatment strategies, orthopaedic surgeons need to understand the complex nature of the distal tibiofibular joint, pitfalls associated with treatment, and current evidence regarding management of syndesmotic injuries.

Anatomy

The distal tibiofibular joint comprises the convex distal aspect of the fibula and the concave lateral aspect of the distal end of the tibia, and is defined as a syndesmotic articulation without articular cartilage. Ankle joint congruity is important for load distribution and preventing secondary joint degeneration[5-7]. While very subtle, the fibular motion at the syndesmosis is essential for maintaining ankle congruity[8,9].

Normal motion of the ankle requires rotation, translation, and migration of the fibula at the syndesmosis to accommodate the trapezoidal shape of the talus. In plantar flexion, the fibula migrates distally, translates anteromedially, and internally rotates. With dorsiflexion, the fibula migrates proximally, translates posterolaterally, and externally rotates. Externally rotating the foot causes medial translation, posterior displacement, and external rotation of the fibula through the syndesmosis[10].

The distal tibiofibular syndesmosis comprises four distinct ligaments (Fig. 1), including the interosseous ligament, the anterior inferior tibiofibular ligament, the posterior inferior tibiofibular ligament, and the inferior transverse ligament. The interosseous ligament represents the thickened distal

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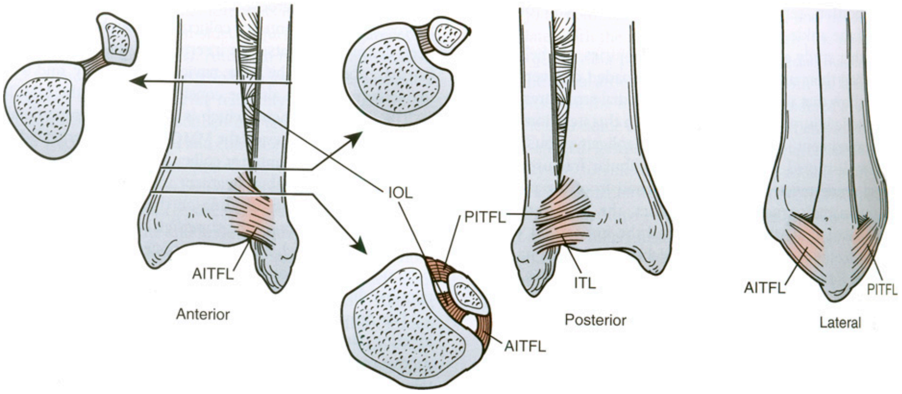

Fig. 1
Drawing of the ligamentous anatomy of the distal tibiofibular syndesmosis with anterior, posterior, lateral, and axial cut views. AITFL = anterior inferior tibiofibular ligament, IOL = interosseous ligament, PITFL = posterior inferior tibiofibular ligament, and ITL = inferior transverse ligament. (Reproduced, with permission, from: Davidovitch RI, Egol KA. Ankle fractures. In: Bucholz RW, Heckman JD, Court-Brown CM, Tornetta P, editors. Rockwood and Green's fractures in adults. 7th ed. Philadelphia: Lippincott Williams & Wilkins; 2010. Figure 57-12.)

portion of the interosseous membrane. The anterior inferior tibiofibular ligament originates from the anterolateral tubercle of the tibia and inserts at the anterior tubercle of the fibula. The posterior inferior tibiofibular ligament originates from the posterior tubercle of the tibia and inserts at the posterior edge of the lateral malleolus. The fibrocartilaginous inferior transverse ligament forms the distal portion of the posterior inferior tibiofibular ligament, and is often considered the same ligament. The anterior inferior tibiofibular ligament (35%) and deep posterior inferior tibiofibular ligament (33%) contribute the most to ankle stability, followed by the interosseous ligament (22%) and superficial posterior tibiofibular ligament (9%)[11].

McKeon et al. examined the vascular components of cadaveric ankle specimens[12] (Fig. 2). In 86% of the specimens, the anterior syndesmotic ligaments were predominantly vascularized by the anterior branch of the peroneal artery. In 63% of the specimens, the anterior syndesmotic ligaments were only vascularized by the anterior branch of the peroneal artery. The posterior branch of the peroneal artery provided the predominant blood supply to the posterior syndesmotic ligaments in 100% of the specimens. The anterior branch perforated the interosseous membrane at an average height of 3 cm proximal to the ankle joint. Therefore, the blood supply to the anterior syndesmotic ligaments is at considerable risk of injury.

A recent study found a positive correlation between the number of blood vessels and the number of free nerve endings in the ankle[13]. The anterior inferior tibiofibular ligament was innervated by Ruffini endings, a class of slowly adapting mechanoreceptors that respond to sustained pressure.

Mechanism of Injury

The most common mechanisms of syndesmotic injury are ankle external rotation and hyperdorsiflexion, but other mechanisms do occur[14-17]. Activities that produce these mechanisms include sports, such as football and soccer, as well as low-energy trauma, such as falling on the stairs or slipping on the ice. External rotation injuries may occur with the ankle in pronation or supination. Damage to the syndesmotic ligaments may occur either in isolation or with an associated fracture. Typical fracture patterns (Fig. 3) include pronation-external rotation fractures (PER or Weber type C), supination-external rotation fractures (SER or Weber type B), and proximal fibular fractures with associated syndesmotic injury (Maisonneuve fractures)[18,19].

Diagnosis

Isolated Syndesmotic Injuries

Patients with isolated syndesmotic injuries, or so-called high ankle sprains, generally present with acute ankle instability, pain, and functional deficits[20]. The history should include the mechanism of injury, previous injuries or surgical procedures,

Fig. 2
Vascular anatomy at the distal tibiofibular syndesmosis, showing the peroneal artery (A) and an anterior branch (B) of the peroneal artery. The arrow indicates the posterior branch of the peroneal artery. (Reproduced from: McKeon KE, Wright RW, Johnson JE, McCormick JJ, Klein SE. Vascular anatomy of the tibiofibular syndesmosis. J Bone Joint Surg Am. 2012 May 16;94[10]:931-8.)

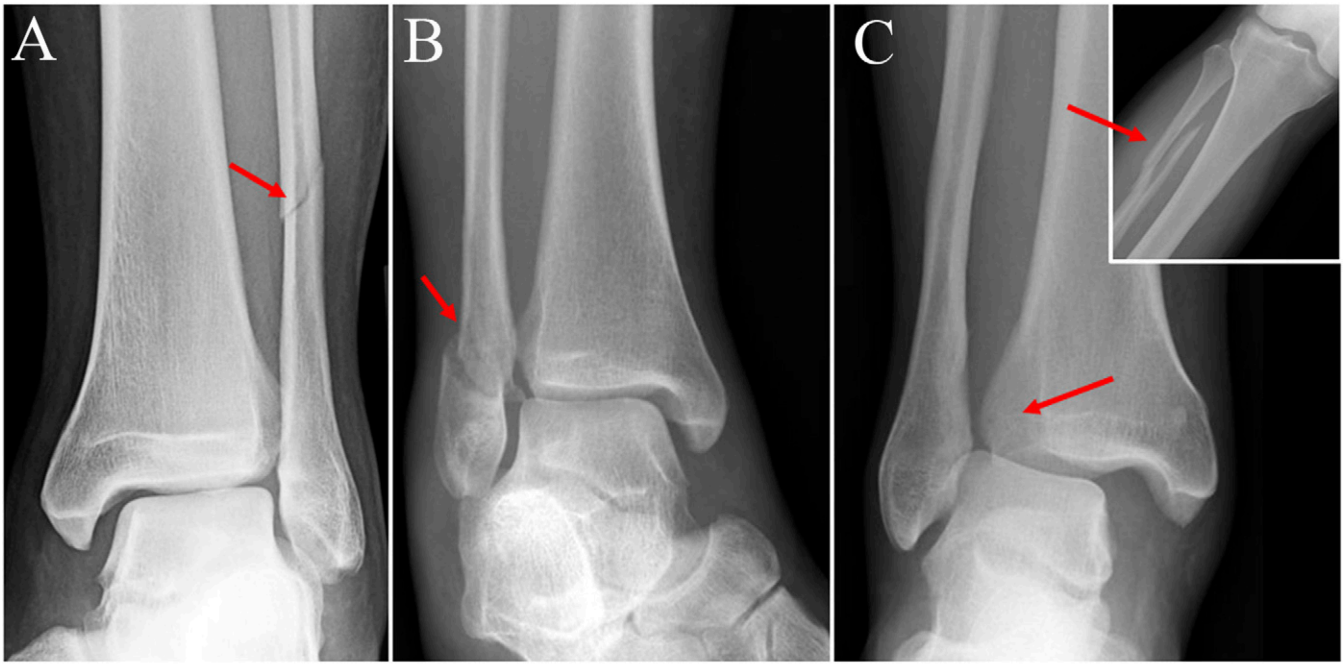

Fig. 3

Radiographs of ankles with common injury patterns associated with syndesmotic injury (arrows), demonstrating a pronation-external rotation or Weber type-C fracture (**Fig. 3-A**), a supination-external rotation or Weber type-B fracture (**Fig. 3-B**), and a Maisonneuve fracture, with an inset showing a typical proximal fibular fracture associated with this injury (**Fig. 3-C**).

and symptoms of instability. Mechanism of injury is critical, as it indicates the potential for syndesmotic disruption.

Stress examinations are useful for diagnosis (Table I). The external rotation stress test entails stabilization of the leg with the knee in 90° of flexion, followed by external rotation of the foot[21-23]. The squeeze test entails compression of the proximal part of the fibula to the tibia, separating the two bones distally[23,24]. The crossed-leg test entails crossing the injured leg over the uninjured leg while the patient is seated, followed by gentle downward pressure to the knee of the injured leg[25]. The forced dorsiflexion test entails forcing the ankle into dorsiflexion, and then repeating this maneuver while compressing the distal end of the tibia and fibula together either manually or with athletic tape[26]. Decreased pain with compression suggests syndesmotic injury.

Physical examination can be conducted after three to five days of rest, ice, compression, and elevation (RICE) and non-steroidal anti-inflammatory drugs without sacrificing diagnostic accuracy[27-29]. However, as many as 20% of syndesmotic injuries may go undetected on clinical examination[30].

Three radiographic parameters have been defined for the diagnosis of syndesmotic injury (Fig. 4), including tibiofibular overlap, tibiofibular clear space, and medial clear space[31-34]. The tibiofibular overlap should normally be >6 mm in the anteroposterior radiograph and >1 mm in the mortise radiograph as measured 1 cm proximal to the tibial plafond. Tibiofibular clear space should be <6 mm in both the anteroposterior and mortise radiographs as measured 1 cm proximal to the tibial plafond. Medial clear space should be less than or equal to the clear space between the talar dome and the tibial plafond. Decreased tibiofibular overlap, increased tibiofibular clear space, and increased medial clear space on either weight-bearing or non-weight-bearing radiographs indicate syndesmotic disruption. Tibiofibular clear space is the most reliable measure because it is not affected by the position of the leg relative to the x-ray beam[32].

Gravity or external rotation stress radiographs can differentiate between frank diastasis (evident on static radiographs) and latent diastasis (evident only on stress radiographs)[15]. Diastasis occurs primarily with posterior displacement of the fibula and is best visualized in the lateral radiograph[35]. Comparisons with radiographs of the contralateral limb are helpful if there is doubt about the presence of diastasis.

While radiographic evaluation is effective in moderate to severe injuries, radiographic evaluation often fails to detect subtle syndesmotic injuries[31,32,36]. Other imaging modalities, such as computed tomography (CT), can detect minor syndesmotic diastasis not apparent on radiographs[37]. Magnetic resonance imaging (MRI) is also a highly sensitive and specific modality for diagnosing syndesmotic injury[38-40].

Syndesmotic Injuries with Associated Malleolar Fractures

Malleolar fractures increase the concern for syndesmotic injury. One study has found that 39% of Weber type-B SER-4 ankle fractures demonstrated syndesmotic instability[41]. However, standard radiographs and biomechanical criteria are inadequate for diagnosing syndesmotic disruptions in malleolar fractures[42]. Diagnosis relies increasingly on intraoperative

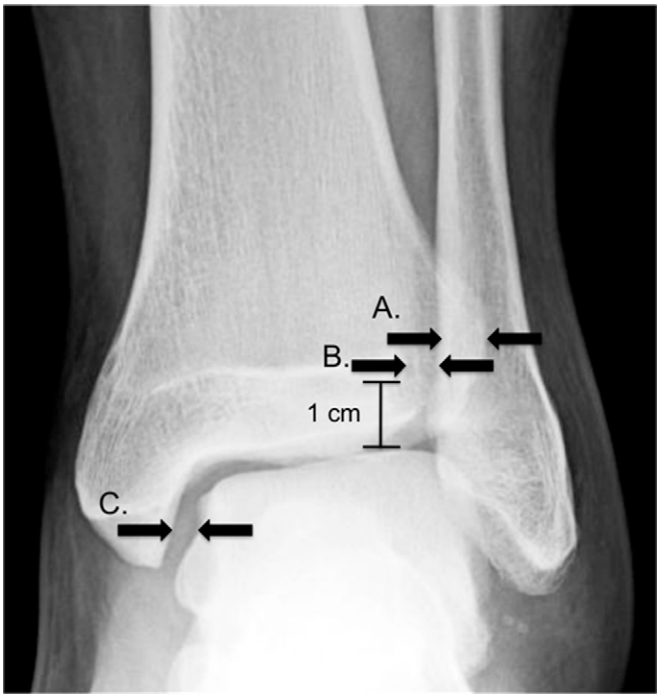

Fig. 4
Common radiographic measurements for diagnosing syndesmotic injuries, including tibiofibular overlap (A), tibiofibular clear space (B), and medial clear space (C). Tibiofibular overlap and tibiofibular clear space are measured 1 cm proximal to the plafond.

stress-testing following malleolar fixation. It is important to intraoperatively stress all operatively treated ankle fractures, as many syndesmotic injuries do not have typical fracture patterns. Tornetta et al. found that 45% of operatively treated SER-4-equivalent fractures demonstrated syndesmotic instability on intraoperative stress examination[43]. Two commonly used intraoperative stress tests are the hook test and the external rotation test under fluoroscopy (Table I)[44]. In the hook test, the surgeon pulls the lateral malleolus with a bone hook while stabilizing the tibia. Lateral movement of the fibula of >2 mm of indicates a positive hook test. For the external rotation stress test, the tibia is stabilized while the foot is externally rotated under fluoroscopy. Increased medial clear space indicates a positive external rotation stress test. Pakarinen et al. prospectively compared the effectiveness of the hook test and the external rotation test[44]. While both tests showed excellent interobserver agreement, the sensitivity of both tests was poor, suggesting that many syndesmotic disruptions go undetected.

A standardized protocol for both the hook test and external rotation stress test improves consistency. Jenkinson et al. developed a standardized external rotation stress test using a linear strain gauge and a fracture reduction F-tool[45]. Using the linear strain gauge, consistent and precise external rotation forces can be applied to the ankle mortise.

Similarly, a cadaveric study found that any lateral forces of >100 N do not substantially increase tibiofibular clear space in specimens with dissected syndesmotic ligaments, suggesting that 100 N of lateral force serves as a good benchmark for a standardized hook test[46]. Evidence also suggests that the accuracy of the hook test may improve by applying force in the sagittal plane and assessing the amount of displacement in the lateral radiograph[47].

Stress testing of the contralateral extremity helps to account for individual anatomical differences[48].

Treatment

Conservative Treatment

Most isolated syndesmotic injuries can be treated conservatively. Williams et al. proposed a three-phase treatment plan[26]. Phase I focuses on protecting the ankle and managing pain and edema with immobilization, limited weight-bearing, light ankle motion exercises, rest, ice, compression, and elevation. Patients transition to Phase II when pain and edema are well controlled and the patient can walk with minimal antalgic gait. Phase II includes strength and proprioceptive exercises, progressing from low-intensity exercises with high repetitions to high-intensity exercises with low repetitions. Patients who do not plan to return to athletics can continue on Phase II until asymptomatic. Patients who desire to resume athletic activities transition to Phase III when they are able to jog or hop without pain. Phase III includes rigorous strengthening exercises and sports-specific movements. Patients with tibiofibular diastasis and persistent symptoms despite conservative management may benefit from operative treatment[49-51].

Operative Fixation

Indications

Traditionally, all SER-type ankle fractures with associated syndesmotic injury were treated operatively. However, evidence suggests that SER-4 ankle fractures can be treated without syndesmotic fixation. Pakarinen et al. performed a stress test on SER-4 ankle fractures intraoperatively following osseous fixation[52]. If the stress test was positive, the patient was randomized to either syndesmotic fixation or no syndesmotic fixation. At the one-year follow-up, no significant differences existed in functional outcomes between the groups.

Reduction

A cadaveric study found that variations in the angulation of reduction clamps and subsequent syndesmotic screw placement can cause iatrogenic syndesmotic malreduction[53]. Clamps placed at 15° and 30° of angulation in the axial plane displaced the fibula in external rotation and caused overcompression of the syndesmosis. However, while significant, the magnitudes of the displacements were small. Additionally, a cadaveric study found that clamp placement in neutral anatomical axis reduced the syndesmosis most accurately, while an obliquely placed clamp resulted in syndesmotic malreduction[54].

Reduction quality cannot be reliably determined with intraoperative fluoroscopy or standard radiographs. Cadaveric data suggest that fixation of the fibula in as much as 30° of

TABLE I Clinical and Intraoperative Stress Test Names, Descriptions, and Positive Indicators for Syndesmotic Injuries

Test	Description	Positive Result:
Clinical stress tests		
External rotation	Both the knee and the ankle are stabilized in 90° of flexion and the foot is externally rotated	Pain over the syndesmosis
Squeeze test	The proximal ends of the tibia and fibula are compressed	Pain over the syndesmosis
Crossed-leg test	With the patient sitting and both knees in 90° of flexion and feet on the ground, the injured leg is lifted and the ankle is placed on the superior aspect of the uninjured knee; gentle downward pressure is applied to the knee of the injured leg	Pain over the syndesmosis
Forced dorsiflexion test	The ankle is manipulated into dorsiflexion, then the maneuver is repeated while compressing the tibia and fibula together	Decrease in pain over the syndesmosis
Intraoperative stress tests		
External rotation	The F-tool is applied to the medial aspect of the forefoot and lateral aspect of the hindfoot; the tibia is stabilized and 7.2 Nm of external rotation force is applied using a linear strain gauge	Increased medial clear space at the ankle mortise
Hook test	100 N of force is applied to the lateral malleolus with a bone hook; the syndesmosis is assessed under fluoroscopy in both the lateral and anteroposterior radiographs	>2 mm of lateral movement of the lateral malleolus

external rotation may go undetected using intraoperative fluoroscopy[55]. Retrospective analysis of 253 intraoperative three-dimensional scans made after reduction under fluoroscopy revealed malreduction in 33% of the patients[56]. The most common malreduction was fibular malpositioning, followed by malreductions of the fracture. The primary fibular malpositions were anterior displacement and internal rotation of the distal end of the fibula.

Fixation Method

Syndesmotic Screws

Considered the so-called gold standard, syndesmotic screw fixation entails the placement of screw(s) across the syndesmosis from the lateral aspect of the fibula into the tibia. Fixation can be achieved with single or double screws, metal or bioabsorbable screws, 3.5-mm or 4.5-mm screws, transsyndesmotic or suprasyndesmotic screws, and with tricortical or quadricortical fixation.

Double screws and 4.5-mm screws provide stronger mechanical fixation[35,57]. Two-hole locking plates (with 3.2-mm screws) provide greater stability to torque compared with 4.5-mm quadricortical fixation in Maisonneuve fractures[58]. However, while the strength of fixation stabilizes the joint, it eliminates normal motion between the tibia and fibula[59].

Suture Button

Suture-button fixation represents a promising alternative. Following reduction, a hole is drilled through the fibula and tibia parallel to the ankle joint[60]. Polyester suture is then passed through and secured at both ends with buttons. Although this does not provide fixation as rigid as syndesmotic screws, it may facilitate motion of the distal tibiofibular joint.

Posterior Malleolar Fixation

Recent evidence indicates that fixation of the posterior malleolus with an intact posterior inferior tibiofibular ligament adequately stabilizes the syndesmosis[61,62]. The posterior malleolus can be fixed utilizing percutaneous anterior-to-posterior screws when the fragment is minimally displaced. An open posterolateral surgical approach to the ankle with antiglide plate placement is required for large fragments or if substantial displacement of the articular surface exists[63].

Outcomes and Complications

Conservative Treatment

A systematic review by Jones and Amendola identified six clinical studies evaluating outcomes after conservative treatment[64]. All studies showed prolonged recovery in syndesmotic sprains compared with lateral ankle sprains (Table II). While none of these studies utilized functional outcome measures, Nussbaum et al. found that injury to the interosseous membrane proximal to the ankle joint correlated with a longer time to return to activity after conservative treatment compared with lateral ankle sprains[22]. Taylor et al. reported an average time to full activity of thirty-one days for football players following conservative treatment[65].

TABLE II Conservative Treatment Outcome Studies for Isolated Syndesmotic Injuries

Conservative Treatment				
Study	Description	No. of Patients	Level of Evidence	Summary
Boytim et al.[21] (1991)	Retrospective	43	III	Athletes with syndesmotic sprains missed significantly more games and practices than athletes with lateral ankle sprains
Gerber et al.[115] (1998)	Prospective	104	III	Syndesmotic sprains had more residual symptoms than other ankle sprains
Nussbaum et al.[22] (2001)	Prospective	60	III	Patient-rated outcomes of good or excellent at 6-mo follow-up; at 6-mo follow-up, 6 of 53 patients reported occasional ankle pain or stiffness and 4 reported recurrent ankle sprains
Wright et al.[77] (2004)	Retrospective	19	III	Average time of recovery for hockey players with syndesmotic injuries was 45 days compared with 1.4 days for players with lateral ankle sprains
Hopkinson et al.[24] (1990)	Retrospective	13	IV	Syndesmotic sprains had longer average recovery time than did other severe ankle sprains; 9 of 10 patients with a syndesmotic sprain who were available for follow-up developed heterotopic ossification
Taylor et al.[65] (1992)	Retrospective	44	IV	Ankle function was rated as good to excellent for 86% of patients and as poor for none; all patients with fair results had recurrent ankle sprains; and half of the patients with radiographs developed heterotopic ossification

Operative Fixation

Syndesmotic Screw

There are no major differences in functional outcomes between single and double screws[66,67], tricortical and quadricortical screws[68,69], transsyndesmotic and suprasyndesmotic screws[70], stainless steel and titanium screws[69], or metal and bioabsorbable screws[71-75](Table III).

Suture Button

A recent systematic review found that suture-button fixation yielded American Orthopaedic Foot & Ankle Society (AOFAS) scores at twelve and twenty-eight months similar to those for screw fixation[76]. Patients with suture-button fixation also returned to work earlier and had less frequent need for implant removal compared with those who had screw fixation. While a suture button is more expensive than screws and lacks conclusive evidence of superiority, the decreased need for surgical removal may make this technique more cost-effective[77-82] (Table III).

Posterior Malleolar Fixation

Gardner et al. found no complete tears of the posterior inferior tibiofibular ligament on MRI in fifteen patients with PER-4 ankle fractures involving the posterior malleolus[61]. They randomly assigned ten cadaveric specimens with replicated fracture patterns to either posterior malleolar fixation or syndesmotic fixation. Posterior malleolar fixation restored stiffness to 70%, and syndesmotic fixation restored stiffness to 40% of that noted in the intact specimens.

Miller et al. prospectively treated thirty-one unstable ankle fractures with preoperatively confirmed syndesmotic injuries and an intact posterior inferior tibiofibular ligament with (1) open posterior malleolar fixation whenever the posterior malleolus was fractured, regardless of fragment size; (2) locked syndesmotic screws in the absence of posterior malleolar fracture; or (3) combined fixation in fracture-dislocations and severe soft-tissue injury to the other ankle ligaments[62]. Postoperative and follow-up Foot and Ankle Outcome Scores were similar in the three groups, suggesting that patients with syndesmotic injuries and an intact posterior inferior tibiofibular ligament receiving posterior malleolar fixation have functional outcomes at least equivalent to patients with syndesmotic screw fixation.

Complications

Malreduction

Anatomic reduction of the syndesmosis is essential for improving functional outcomes and avoiding posttraumatic osteoarthritis[6,83-85]. A prospective study by Sagi et al. found that, at the time of the two-year follow-up, individuals with a malreduced syndesmosis had significantly worse functional outcomes

TABLE III Syndesmotic Screw and Suture-Button Fixation Outcome Studies

Study	Description	No. of Patients	Level of Evidence	Summary*
Syndesmotic screw				
Thordarson et al.[74] (2001)	Prospective	32	I	No differences with regard to fixation failures, wound complications, range of motion, or subjective complaints in comparison of stainless-steel and bioabsorbable screw fixation
Høiness et al.[67] (2004)	Prospective	64	I	Comparison of single quadricortical screws and double tricortical screws; tricortical group had better functional outcomes at 3 mos, but no difference between groups at 1 yr
Kaukonen et al.[73] (2005)	Prospective	38	I	Ankles with bioabsorbable screws had less swelling than did ankles with metal screws; no differences in range of motion or radiographic measures
Moore et al.[68] (2006)	Prospective	127	I	No differences between tricortical and quadricortical fixation with regard to screw breakage, loss of reduction, or hardware removal
Wikerøy et al.[66] (2010)	Prospective	48	II	No difference in functional outcome scores or osteoarthritis between single quadricortical screw fixation group and double tricortical screw fixation group at 8.4-yr follow-up
Kukreti et al.[70] (2005)	Retrospective	36	III	No clinical or radiographic differences in outcomes between transsyndesmotic and suprasyndesmotic screw fixation
Sinisaari et al.[75] (2002)	Case series	43	IV	No difference between stainless-steel screws and bioabsorbable screws with regard to radiographic and CT measurements, range of motion, or duration of sick leave
Hovis et al.[72] (2002)	Case series	33	IV	No adverse events in 23 patients available for follow-up; 83% of patients had excellent results, and 17% had good results
Ahmad et al.[71] (2009)	Retrospective	75	IV	Mean AOFAS score was 90 of 100 and mean VAS for pain was 1.8 of 10 at the time of final follow-up after bioabsorbable screw fixation
Suture button				
Cottom et al.[80] (2009)	Prospective	50	II	No significant differences in outcome scores between suture-button and screw fixation cohorts
Naqvi et al.[60] (2012)	Prospective	46	II	No significant difference in AOFAS score or Foot and Ankle Disability Index between suture-button and screw fixation; no malreductions in suture-button cohort and 5 malreductions in screw fixation cohort
Thornes et al.[78] (2005)	Prospective	16	III	Patients who had suture-button fixation had quicker return to work and better AOFAS scores compared with a matched control group with screw fixation
Willmott et al.[79] (2009)	Retrospective	6	IV	Good functional outcomes and good patient satisfaction after suture-button fixation; 2 of 6 patients had soft-tissue irritation and required implant removal
Qamar et al.[81] (2011)	Retrospective	16	IV	Mean AOFAS score was 86.88 (range, 48-100) at 2-yr follow-up; 2 of 16 had wound complications treated with antibiotics
Degroot et al.[82] (2011)	Retrospective	24	IV	Mean AOFAS score was 94; 24% of patients required implant removal; 4 patients showed osteolysis, and 3 patients developed heterotopic ossification

*CT = computed tomography, AOFAS = American Orthopaedic Foot & Ankle Society, and VAS = visual analog scale.

TABLE IV Recommendations for Care

Recommendations	Grade of Evidence*
Radiographic evaluation is effective in diagnosing moderate to severe syndesmotic injuries, but often fails to detect subtle ones	B
It is important to intraoperatively stress all surgically treated ankle fractures to evaluate latent syndesmotic injury	C
Patients with distal tibiofibular diastasis and persistent symptoms despite conservative management can benefit from delayed operative treatment	C
Posterior malleolar fixation can restore syndesmotic stability	C
Anatomic reduction of the syndesmosis may not be reliably determined with intraoperative fluoroscopy or standard radiographs	C
Anatomic reduction of the syndesmosis is essential for improving functional outcomes and avoiding posttraumatic osteoarthritis	C
Several strategies, such as intraoperative three-dimensional imaging, postoperative computed tomography, and imaging of the contralateral syndesmosis, improve rates of anatomical reduction	C
Syndesmotic screw removal may provide immediate improvement to outcome scores, yet screw removal is not without risks	C
Use of 3 to 4 quadricortical syndesmotic screws should be considered for patients who are at a higher risk of fixation failure	I
Most isolated syndesmotic injuries can be treated conservatively	I

*Grade A indicates good evidence (Level-I studies with consistent findings) for or against recommending the intervention; Grade B, fair evidence (Level-II or III studies with consistent findings) for or against recommending the intervention; Grade C, conflicting or poor-quality evidence (Level-IV or V studies) not allowing a recommendation for or against the intervention; and Grade I, there is insufficient evidence to make a recommendation[116].

than individuals with anatomic reductions[86]. Similarly, a study comparing suture-button and screw fixation found that malreduction was the only variable that affected clinical outcomes[87]. A cadaveric study found that compression of the syndesmosis during screw fixation does not limit maximum dorsiflexion, suggesting that anatomic reduction of the syndesmosis is of greater concern than overcompression[88].

Syndesmotic malreduction is commonplace. Recent studies have noted syndesmotic malreduction in 25.5% to 52% of patients[55,86,89-91]. Traditional radiographs and fluoroscopy provide inaccurate assessment of syndesmotic reduction, especially concerning fibular external rotation[55,56,90].

Several strategies improve rates of anatomical reduction. Direct visualization of the tibiofibular joint can reduce the malreduction rate from approximately 50% to 15%[86,91]. Intraoperative three-dimensional imaging can also accurately detect malreductions[56,92]. While intraoperative three-dimensional imaging exposes the patient to additional radiation, it provides a noninvasive intraoperative assessment, improving reduction accuracy and minimizing the need for revision. Postoperative CT scans reveal syndesmotic malreductions as well, but it is unclear whether the benefits of finding malreductions postoperatively outweigh the risks of revision surgery.

While there may be substantial variations in ankle morphology between individuals[48], variation between contralateral ankles of one individual is small[93]. Images of the contralateral, uninjured ankle can be used to assess the accuracy of reduction of the syndesmosis[94].

Song et al. sought to determine the effect of screw removal on the alignment of the distal tibiofibular joint[89]. Fifteen patients requiring syndesmotic screw placement were evaluated prospectively. Initial postoperative CT scans revealed that six of fifteen patients had malreductions. One month after screw removal and returning to weight-bearing, five of the six initial malreductions reduced spontaneously. Although limited by small sample size and lack of functional outcomes, patients with intact implants and symptomatic malreduction may only require simple screw removal rather than extensive revisions.

Hardware Failure and Screw Removal

Syndesmotic fixation limits fibular biomechanics during normal motion of the ankle[59,95]. As patients increase weight-bearing and resume activities, shear stresses can cause syndesmotic screws to break. Screw breakage has been reported to occur in 7% to 29% of patients who have had fixation, depending on the time of screw removal[96]. Stuart and Panchbhavi found that 3.5-mm screws were significantly more likely to break than were 4 mm or 4.5-mm screws[97].

Fixation failure prior to complete healing can result in reduction loss and the need for revision. Syndesmotic screws are typically left in place for six to twelve weeks to allow for ligamentous healing[98]. Syndesmotic screw removal at six weeks reduces the rate of implant failure, but increases the rate of recurrent diastasis[99]. Studies have found no significant difference in outcomes between patients with retained screws and those with the screws removed[83,100,101]. However, several studies have shown that patients with retained broken screws had better functional outcome scores than patients with retained intact screws[101,102]. Hamid et al. found that individuals with retained broken screws had a mean AOFAS score (and standard deviation) of 92.40 ± 12.69 compared with 83.07 ± 13.59 for those with retained intact screws[101].

One recent study demonstrated improved outcomes after implant removal. Miller et al. evaluated twenty-five consecutive patients who had an ankle fracture with syndesmotic injuries and underwent fixation with locked syndesmotic screws and plates[103]. Ankle motion and functional outcome scores showed significant improvement at the two-week postoperative follow-up evaluation after screw removal. However, the improvements plateaued, with no significant differences found at the twelve-week follow-up.

The findings outlined above suggest that restoration of normal fibular motion and alignment of syndesmosis profoundly impact functional outcomes, whether through implant removal, loosening, or breakage. These findings suggest that removal of symptomatic intact screws may be prudent, rather than waiting for breakage or loosening. Screw removal is not without risk, however. Schepers et al. demonstrated a 22.4% complication rate following routine removal of syndesmotic screws, including infection in 9.2% and recurrent diastasis in 6.6%[104].

Obese and Neuropathic Patients

Obese patients and those with neuropathic conditions such as diabetes mellitus are at high risk for implant complications. Mendelsohn et al. found a strong association between obesity and loss of syndesmotic reduction[95]. Two hundred and thirteen consecutive patients who had syndesmotic fixation were divided into two cohorts: those who were obese (n = 102) and those who were nonobese (n = 111). Fixation failed in 15% of the obese patients compared with 1.8% of nonobese patients (p = 0.0005). After adjusting for injury severity, the authors found that obese patients were twelve times more likely to lose syndesmotic reduction than were nonobese patients. Furthermore, Wukich and Kline found that patients with complicated diabetes were 3.4 times more likely to have malunion, nonunion, or Charcot arthropathy and five times more likely to need revision surgery following ankle fractures compared with patients with uncomplicated diabetes[105]. Perry et al. demonstrated that fibular plate fixation with multiple large-fragment syndesmotic screws is a viable salvage method for neuropathic patients following implant failure[106]. We recommend using three or four quadricortical syndesmotic screws in patients at higher risk for fixation failure[107].

Heterotopic Ossification

Several studies have described the development of heterotopic ossification following syndesmotic disruption[24,65,108,109]. Taylor et al., in a report on fifty syndesmotic sprains in forty-four football players, found that 50% of the patients with radiographs developed heterotopic ossification[65]. Böstman reported a higher prevalence of heterotopic ossification after fixation with bioabsorbable screws[110].

Heterotopic ossification can lead to ankle synostosis, resulting in pain and abnormal ankle kinematics. The prevalence of syndesmotic synostosis after an ankle fracture has been reported to range from 1.7% to 18.2%[111-114]. The pathophysiology of heterotopic ossification and synostosis of the ankle is poorly understood. Additionally, limited data exist with regard to the relationship between heterotopic ossification and functional outcome scores.

Overview

Despite the amount of research devoted to syndesmotic injuries, many unanswered questions remain. Syndesmotic injuries are difficult to diagnose and treat, with malreductions remaining commonplace. The effectiveness of the gold-standard syndesmotic screw fixation method is being brought increasingly into question. Obtaining anatomic reduction is essential, and the use of intraoperative three-dimensional imaging or open visualization may be warranted. The need for routine screw removal remains controversial. Although screw removal restores normal motion of the fibula and may allow for spontaneous reduction of malreductions, the data remain inconclusive. A complete summary of recommendations for care is given in Table IV. ■

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