Operative Treatment of Syndesmotic Injuries With Assisted Arthroscopic Reduction

Taylor N. Cabe, BA, Kaitlyn A. Rodriguez, BA, and Mark C. Drakos, MD

Abstract: There continues to be a lack of consensus on the proper treatment of syndesmotic injuries in the literature. Currently, much of the operative debate lies between using a suture-button technique or transsyndesmotic screw fixation to treat the injury. There are further arguments surrounding screw fixation involving the size and number of the screws, the number of cortices, and whether or not the hardware is to be removed. For patients presenting with a syndesmotic injury, it is important to properly diagnose and address the type of injury in order to prevent long-term morbidity and ultimately, degenerative arthritis. In the case of unstable syndesmotic injuries, we advocate the use of screw fixation, using 2, fully threaded, 4.0-mm cortical screws through 4 cortices and removal of the hardware 3 months postoperatively.

Level of Evidence: Level IV.

Key Words: syndesmotic injuries, screw fixation, syndesmosis, ankle fractures, treatment

(*Tech Foot & Ankle* 2018;00: 000–000)

HISTORICAL PERSPECTIVE

Ankle injuries are common in athletes accounting for up to one-third of all injuries in sports such as basketball and football.[1] When compared with lateral ankle sprains, syndesmotic injuries (or high ankle sprains) are less well understood due their relative infrequency.[2] Previous reports indicate syndesmotic injuries occur with 1% to 20% of all ankle injuries, with a higher prevalence in sports-related trauma.[1–3] Injuries to the syndesmosis typically involve disruption of the ligamentous complex between the distal fibula and tibia, and potentially occur in conjunction with an ankle fracture.[2,3] Treating syndesmotic injuries is complex, as the severity and degree of injury can vary immensely.[4] Syndesmotic injuries present a diagnostic dilemma, frequently being misdiagnosed due to their rarity and normal radiographic presentation in subtler cases.[2,4–7] Proper diagnosis, evaluation of severity and stability, and subsequent appropriate treatment of these injuries is imperative to reduce the risk of long-term morbidity, posttraumatic arthritis, distal tibiofibular diastasis, chronic ankle pain, and functional problems.[5,8,9]

The primary structures associated with the distal tibiofibular syndesmosis are the tibia, fibula, interosseous membrane, and the 3 ligaments that make up the complex: the anterior inferior tibiofibular ligament (AITFL), the posterior inferior tibiofibular ligament (PITFL), and the interosseous ligament.[10] These 3 ligaments are critical to the stability and function of the ankle mortise.[10] The AITFL and PITFL both serve as stabilizers of the distal tibiofibular articulation in addition to the interosseous ligament, which has been characterized as a buffer to axial tibial loading by transferring some of the weight-bearing load from the tibia to the fibula.[2,10] A fourth ligament, the inferior transverse tibiofibular ligament is sometimes considered as a separate component of the PITFL with a fibrocartilaginous appearance.[2,10] A secondary stabilizer, the deltoid ligament, is not part of the syndesmotic complex; however, it is often injured in addition to the aforementioned syndesmotic ligaments and should be considered when assessing syndesmotic injuries.[10]

The mechanism for a syndesmotic injury is complex due to the variety of anatomic structures involved and the different means of extreme stress in 3 different planes of motion.[2] The most commonly accepted mechanism is forceful external rotation of a planted foot, which causes the talus to rotate about the tibia and the fibula.[2,4,10] This is much different than a lateral ankle sprain, which is typically as a result of inversion when the foot and ankle are plantar flexed.[2] Other proposed mechanisms include eversion of the talus and hyperdorsiflexion, which both cause excessive widening of the ankle mortise.[2,4,10] Athletes who participate in sports where there is planting of the foot and cutting and/or collision with others, such as football, skiing, and ice hockey, are at the greatest risk for syndesmotic injuries.[2,4,9,10]

Determination of proper treatment course typically stems from the classification of ankle sprains based on type and severity of ligament injury. Variation in classification among clinicians can be a common source of controversy in syndesmotic injury management. If there is no diastasis present on radiographs, the ankle is likely stable, and the grade-I injury can most likely be treated nonoperatively.[9,11,12] However, latent diastasis as evidenced by negative standing films but positive stress x-rays or other positive indications during physical examination should also be taken into consideration. The literature remains inconclusive on whether operative or nonoperative treatment is required for these grade-II injuries due to difficulty in confidently detecting the presence or absence of syndesmotic stability affected by a partially disrupted ligament.[12] Conversely, if diastasis is present on plain standing radiographs due to complete rupture of the syndesmotic ligaments, a grade-III injury, the ankle is characterized as unstable and operative management is usually necessary to regain previous functional ability.[9,12,13] Still, lack of understanding of the association between severity of ligament injury and degree of syndesmotic instability has historically presented a problem for directly relating diagnostic classification to determination of treatment. With presence of instability serving as a key determinant in the choice between nonoperative or operative treatment, this association, or current lack thereof, represents an area requiring continued research.[12] Current diagnostic techniques simply do not offer a consistently dependable means for detecting instability.

From the Hospital for Special Surgery, New York, NY.

All patients were enrolled in our department's Foot and Ankle Registry and our Ankle Arthroscopy for Diagnosis and Treatment of Osteochondral Lesion in the Setting of Ankle Fracture study. The Foot and Ankle Registry approved our study and the Registry is approved by our institution's IRB. All patients gave informed consent.

M.C.D.: is a paid consultant and receives royalties from Extremity Medical. M.C.D. is also a paid consultant for Fast Form. Neither of these companies' products are involved in the current paper. The remaining authors declare no conflict of interest.

Address correspondence and reprint requests to Taylor N. Cabe, BA, Research Assistant, Hospital for Special Surgery, 523 East 72nd Street, 5th Floor, New York, NY 10021. E-mail: taylorcabe29@gmail.com.

Further classifications holding implications for determining appropriate treatment include identifying if injury to the syndesmosis is isolated or nonisolated. When there is no associated fracture with the ankle sprain, but disruption of the distal tibiofibular joint, the syndesmotic injury is considered isolated.[12] Nonisolated injuries to the syndesmosis commonly involve an associated fracture, typically, a Weber type C fracture.[12] Weber C fractures are typically caused by external rotation and are often characterized by disruption of the deltoid ligament and a fibular fracture about the ankle joint.[9] Although less common, other fractures that may delineate a nonisolated syndesmotic injury are Weber type B and Maisonneuve proximal fibula fractures.[9,12] Weber type B fractures are also caused by a pronation or supination external rotation mechanism, but occur at the level of the distal tibiofibular joint.[9] Nonisolated syndesmotic injuries almost always require surgical fixation to anatomically reduce the distal tibiofibular joint and to prevent progressive lateral translation of the talus.[9,12]

To date, there is no universally accepted protocol that has been established to treat syndesmotic injuries.[14] Current debates persist with regard to suture-button fixation, such as the TightRope kit (Arthex, Naples, FL), versus screw fixation.[15–19] Because of the limited studies that have been conducted comparing these 2 techniques, it remains unclear which method is best for proper healing of the syndesmosis and has the greatest short-term and long-term benefits.[12] The suture-button technique has risen in popularity because of the decreased frequency of hardware removal, cost-efficiency, and lower reports of malreduction. However, the suture-button still allows for supraphysiological fibula range of motion particularly posteriorly in the sagittal plane.[19,20] Furthermore, there are concerns with regard to late loss of reduction and the ability of the suture-button to truly hold an anatomic reduction in the case of severe injuries with wide diastasis. There have also been reports of superficial wounds, chronic osteomyelitis, movement of the button, and irritation caused by the knots.[12,16–18] As a result, screw fixation remains the "gold standard" technique in treating syndesmotic injuries. Further debate surrounding the screw fixation technique exists with regard to the number of screws, screw diameter, the number of cortices of screw purchase, and whether or not screw removal is necessary, and if so, the timing of removal.[14] In addition, it remains controversial whether or not to fix the deltoid ligament. However, if fixation of the fibula is used to obtain a normal ankle mortise, often the deltoid ligament is indirectly reduced.[21,22]

INDICATIONS AND CONTRAINDICATIONS

Because of variability in severity of injury and instability, diagnosing syndesmotic injuries is one of the most difficult aspects of treatment. With syndesmotic injuries, patients typically complain of pain as a result of palpation over the AITFL and tibia/fibula overlap may be present. In cases where tibiotalar instability persists, the patient's injury will require surgical repair.[12] Assessing the degree of instability of the syndesmosis is the most significant determinant in evaluating whether the injury requires conservative or operative management. Instability can be defined as the presence of supraphysiological motion of the talus relative to the tibia and assessed using plain standing radiographs, stress radiographs using a Telos device and a variety of stress tests, though the external rotation stress test is commonly utilized in our own practice. Indications of instability and thus the need for operative repair to address the syndesmosis include a positive external rotation stress test as indicated by pain, increased medial clear space, and increased widening between the tibia and fibula at the site of the interosseous membrane on radiographs. Specifically, medial clear space of ≥ 4 mm or incongruency compared with the transverse ankle joint clear space is indicative that supraphysiological translation has occurred. Biomechanics studies have indicated that 1 mm of translation can greatly affect the contact stresses at the ankle joint predisposing to future arthrosis.[21,23] As such, if instability is immediately evident based on plain standing radiographs, the authors recommend open reduction and internal fixation (ORIF) and anatomic reduction to improve these contact mechanics at the joint. Indications of instability based on medial clear space and interosseous membrane widening on stress radiographs in combination with pain upon external stress test also typically warrant operative repair. Detection of persistent instability rather than just injury to the ligaments is key, yet many of the currently available indicators are used to detect syndesmotic injury alone rather than instability, thus, again, highlighting the controversy that surrounds indications to repair the syndesmosis operatively.[12]

Indications of subtler syndesmotic injuries or nonisolated injuries can be more difficult to interpret and easily missed upon physical examination and radiographic diagnosis. Conservative management is appropriate for a syndesmotic injury determined to be stable as indicated by negative stress tests or stress x-rays not showing an increased medial clear space or widening.[12] This can include some subluxable syndesmotic injuries which sit in anatomic position until stressed and can often be treated through proper immobilization. If immobilization and anatomic alignment cannot be achieved, surgical treatment will be necessary. Conservative treatment follows a standard protocol of rest, ice, compression, and elevation for 4 to 6 weeks after which the patient can be transitioned into a lace-up ankle brace and progressed through physical therapy as symptoms dictate.[12] Patients are typically non–weight-bearing following initial injury but transition to weight-bearing as tolerated, dictated by pain and symptoms after 3 to 5 days.[12] Other available conservative treatments include PRP or cortisone injection into the AITFL region.[24–26] It should be noted, cortisone injections are more commonly used, especially with athletes, while the effects of PRP injection are still limited and controversial.[24,25]

To date, it remains unclear if subluxable injuries proceed onto late diastasis and require ankle fixation or not. The syndesmotic ligaments generally have good vascularity and heal if appropriately aligned. Late instability in these cases from ligaments that do not heal may exist but is rare and infrequently reported. Some authors have suggested that fixation of these subtler injuries may not alter the long-term result but may hasten return to play and recovery in athletic individuals. One paper advocates operative repair in athletes with a minimum of grade-III isolated syndesmotic injury with frank diastasis.[27] Meanwhile, another study reports a wide variability in time lost from sport due to syndesmotic injury and speculates operative repair may facilitate more predictable and timely return to play.[28] It is controversial if this theoretical benefit outweighs the risks associated with surgery including infection and prominent hardware.

Further presentation of syndesmotic injuries can be detected intraoperatively and are especially useful in identifying damage to the syndesmosis in cases of nonisolated injuries, including malleolar and Maisonneuve fractures. During arthroscopic procedures, the ability to pass a 2.9-mm shaver (Smith & Nephew, Andover, MA) through the medial gutter of the ankle, otherwise known at the arthroscopic drive-through sign, is a clear indicator of instability and damage to the syndesmosis and/or deltoid ligament.[22] In addition, intraoperative external rotation stress tests are used to assess the degree of stability in the ankle throughout the repair process. Increased motion of the fibula, specifically within the sagittal as opposed to coronal plane, indicates instability.[19,29] Intraoperative indication of instability, in the form of the arthroscopic drive-through sign, is significant as it represents one of the few conclusive predictors of instability and takes into consideration the frequency of nonisolated syndesmotic injuries.[12]

PREOPERATIVE PLANNING

Stress tests such as the external rotation stress test, fibular translation, and the squeeze test are used to assess the degree of syndesmotic instability upon physical examination. Frequently, these tests will be positive in the setting of injury and instability. Evaluation of diagnostic accuracy for these tests revealed 71% sensitivity for the external rotation stress test and 88% specificity for the squeeze test. Comparatively, simple tenderness of the syndesmotic ligaments upon palpation has a sensitivity of 92%.[30]

Stability is further assessed through radiographic imaging beginning with anteroposterior, lateral, and oblique x-rays and stress x-rays utilizing a Telos device to analyze the medial clear space and the interosseous membrane. Depending on the severity of the injury, x-ray imaging alone may be all that is required preoperatively. Full-length tib/fib radiographs are indicated if proximal fibula tenderness is present, potentially indicating a Misonneuve injury. If standing x-rays and stress x-rays are negative, it is likely a stable injury and the patient can be treated conservatively with protected weight-bearing in a controlled ankle movement (CAM) boot. If the standing x-rays show incongruency, then operative treatment is indicated and no further workup is necessary. If standing x-rays are negative but stress x-rays are positive or there is a high suspicion of latent instability, then further workup is warranted. This may include magnetic resonance imaging or standing computed tomographic scan to further assess the structural injury. Ultimately, these subtler injuries may require more extensive workup to determine the severity of the injury. Furthermore, as 8.5% of all ankle injuries contain nonisolated injuries to the syndesmosis, magnetic resonance imaging can be used to assess other comorbidities, especially in cases of ankle fractures with suspected osteochondral lesions and associated cartilage or ligament damage (Fig. 1).[12,31] If instability is detected, the authors advocate ORIF to ensure that the ankle remains anatomically reduced to prevent the prospects of future arthrosis.

Once operative treatment is deemed necessary, an arthroscopy-assisted approach is planned. In cases of nonisolated syndesmotic injuries with fractures as comorbidities, measures should be taken to prepare for repair of any chondral injury in addition to the syndesmosis. True unstable syndesmotic injuries have a high incidence of full thickness articular cartilage injuries and thus should be thoroughly evaluated. One study has reported up to 96% of unstable syndesmotic injuries in the setting of ankle fracture also had associated chondral injuries.[31] Cartilage injury may be a source of persistent morbidity and should be addressed at the index procedure whenever feasible.

The senior author (M.C.D) has performed an arthroscopically assisted, ORIF of the syndesmosis on over 60 patients since 2010. We believe that the screw fixation technique including 2, fully threaded, 4.0-mm cortical screws through 4 cortices and removal of the hardware after 3 months postoperatively offers patients the most effective and efficient recovery with the greatest long-term outcome. The use of this technique has been successful in preventing long-term morbidity and posttraumatic arthritis, which may result from an inadequately treated syndesmotic injury.

TECHNIQUE

The patient is placed in supine position on the operating table. After appropriate regional and/or general anesthesia and antibiotics have been administered, an ipsilateral bump is used to position the patella and foot pointing directly vertical.

Arthroscopy

To assess the joint and evaluate the arthroscopic drive-through sign, an arthroscopic approach as previously described by Schairer et al[22] is performed. Standard anteromedial and anterolateral portals are established. Initially, the anteromedial portal serves as the viewing portal and the anterolateral portal is the working portal. The lateral gutter is explored first. If present, visualization of a low fibular fracture should be possible from this position and any fibular fracture fragments can be debrided.

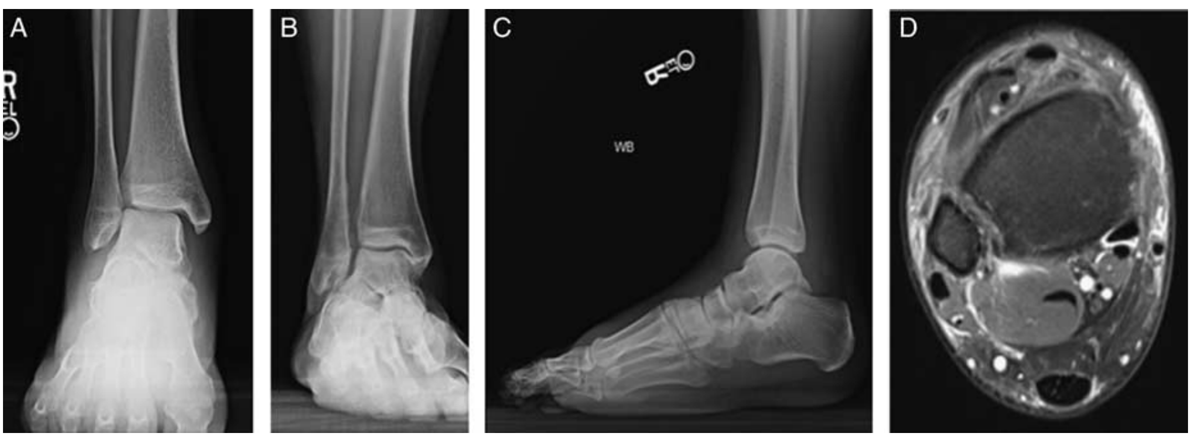

FIGURE 1. Standard anteroposterior (A), oblique (B), and lateral (C) preoperative imaging indicates syndesmotic injury. The anteroposterior view (A) shows an increased medial clear space, the oblique view (B) shows widening at the site of the interosseous membrane between the fibula and tibia. An axial magnetic resonance imaging slice of the spacing between the fibula and tibia (D) also indicates widening.

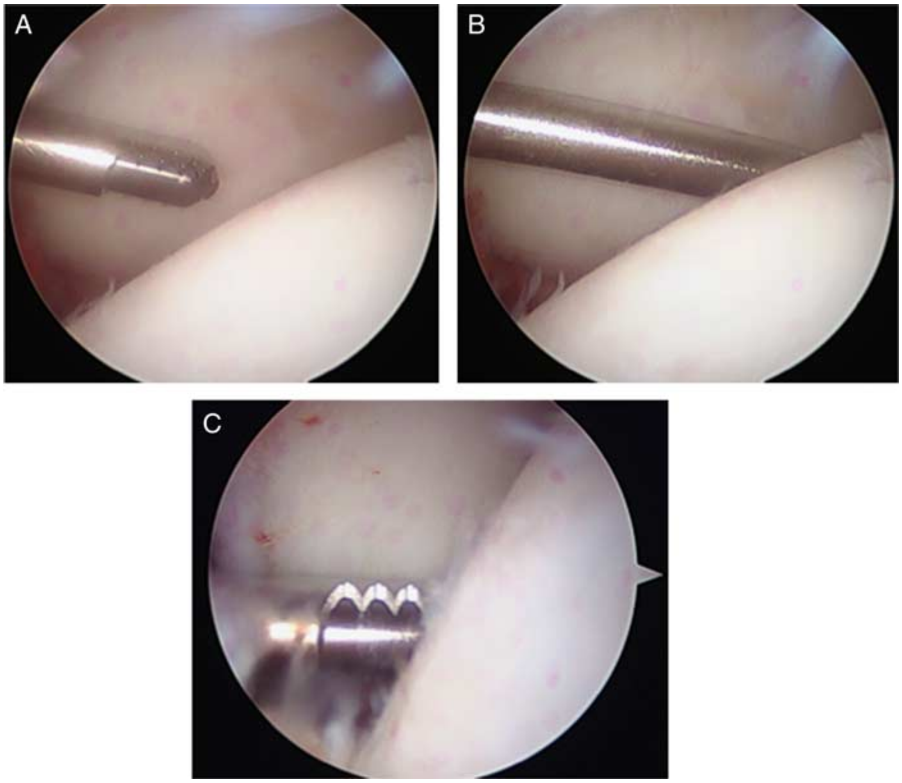

FIGURE 2. A and B, A positive arthroscopic drive-through sign is present when a 2.9-mm shaver can be easily passed between the medial malleolus and talar dome, as shown. C, The arthroscopic drive-through sign is negative when a 2.9-mm shaver cannot be easily inserted between the medial malleolus and talar dome, as shown.

Attention is then turned medially and the anterolateral portal becomes the viewing portal. The deltoid and the medial structures are inspected, and any damage to ligaments or cartilage is evaluated and addressed. In cases of chondral injury, thorough debridement and subsequent placement of bone marrow aspirate taken from the patient's iliac crest mixed with an extracellular cartilage matrix is the senior author's preferred treatment method. Assessment of the medial clear space for the arthroscopic drive-through sign is executed. A positive sign is present if the 2.9-mm shaver (Smith & Nephew) can be easily positioned posteriorly between the talar dome and the medial malleolus (Fig. 2). This is indicative of an unstable injury due to damage to the syndesmosis or the deltoid ligament. Finally, an arthroscopic external rotation stress test is performed during direct assessment of the syndesmosis, specifically the AITFL ligament (Fig. 3). When the syndesmosis is torn, it is often possible to have visualization several centimeters above the joint line.

ORIF

The ORIF portion of the procedure is then performed. Attention is turned to the patient's fibula. A 2-cm incision is made laterally over the fibula. The superficial peroneal nerve is

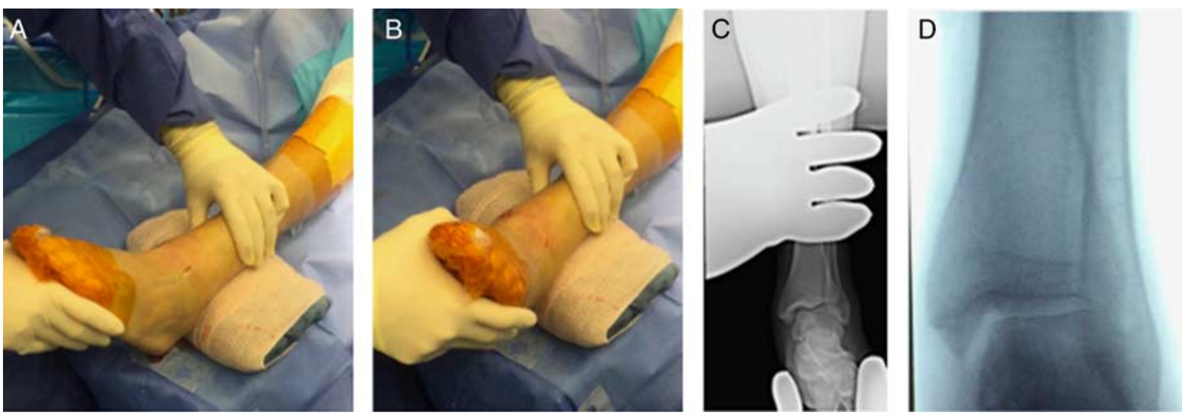

FIGURE 3. A and B, External rotation stress testing is performed intraoperatively to assess syndesmotic widening. C, Fluoroscopy is used for assistance in visualizing the syndesmosis and assessing the medical clear space. D, Increased medial clear space can be seen intraoperatively before screw fixation.

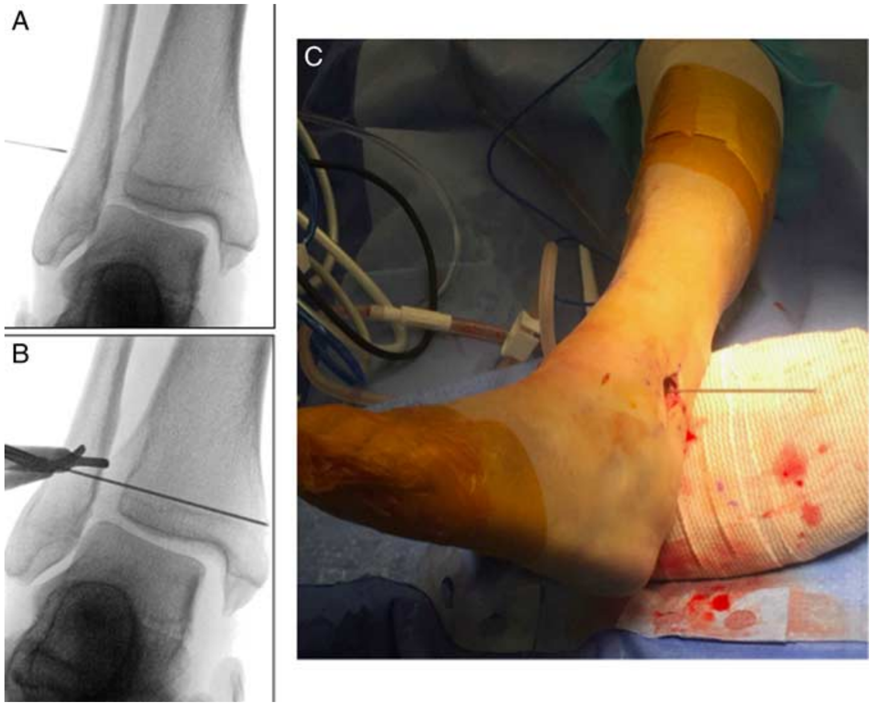

FIGURE 4. A and B, Intraoperative fluoroscopy is used to assist in K-wire placement. C, The K-wire used to aid in screw placement is shown holding the reduced fibula in place.

identified when present and retracted anteriorly, and protected throughout the case. Arthroscopic equipment is introduced and the fibula is reduced under direct visualization. The fibula is held in place with a K-wire (Fig. 4). One study found that using one's thumb for reduction has a better contact stress profile than when a clamp is used due to shifting of the fibula in the sagittal plane with the use of a clamp.[22] A 2 or 3-hole tubular plate is placed proximally on the lateral aspect of the fibula (Fig. 5).

FIGURE 5. A 2-holed tubular plate is shown placed along the lateral aspect of the fibula.

The area of the syndesmosis is drilled across with a 2.5-mm drill bit. Next, a fully threaded, 4.0-mm cortical screw is angled from posterolateral to anteromedial in order to engage the tibia. The screw is angled obliquely from back to front at an angle of 25 to 30 degrees and is directed from the lateral to the medial cortex of the fibula and into the tibia, at right angles to the long axis.[13] It is important the screw be placed approximately at the level of the physeal scar and 3 to 4 cm proximal to the tibiotalar joint, engaging through all 4 cortices. The screw must also be directed parallel to the joint line to avoid displacement of the fibula, either in an inferior or superior direction.

A second, fully threaded 4.0-mm cortical screw is placed parallel to the first, but more proximal. The second screw is placed parallel to the joint line in order to avoid tilting the distal fibula. This screw serves as more of a set screw and is also placed through all 4 cortices (Fig. 6). After the screws have been inserted, an external rotation stress test is performed to assess for continued medial clear space widening of the tibia either medially or laterally in the coronal plane and potential injury to the deltoid. In addition, fluoroscopic films are taken to ensure there is no malreduction of the fibula or notch of the tibia with subluxation of the talus. Final fluoroscopic photos are taken in the anteroposterior, lateral, and oblique planes. The joint is assessed arthroscopically and the arthroscopic drive-through sign should be eliminated. The patient is placed in a non–weight-bearing splint for 2 weeks (Fig. 7).

Repair of the Deltoid Ligament

A stress x-ray of the ankle is taken. If valgus laxity in the form of diastasis between the fibula and tibia or talus is present upon valgus stress, we will repair the deep deltoid ligament. A small, 2-cm incision, is made over the medial aspect of the patient's medial malleolus. A knife is used to dissect sharply through the skin and subcutaneous tissue. Blunt dissection is carried out to

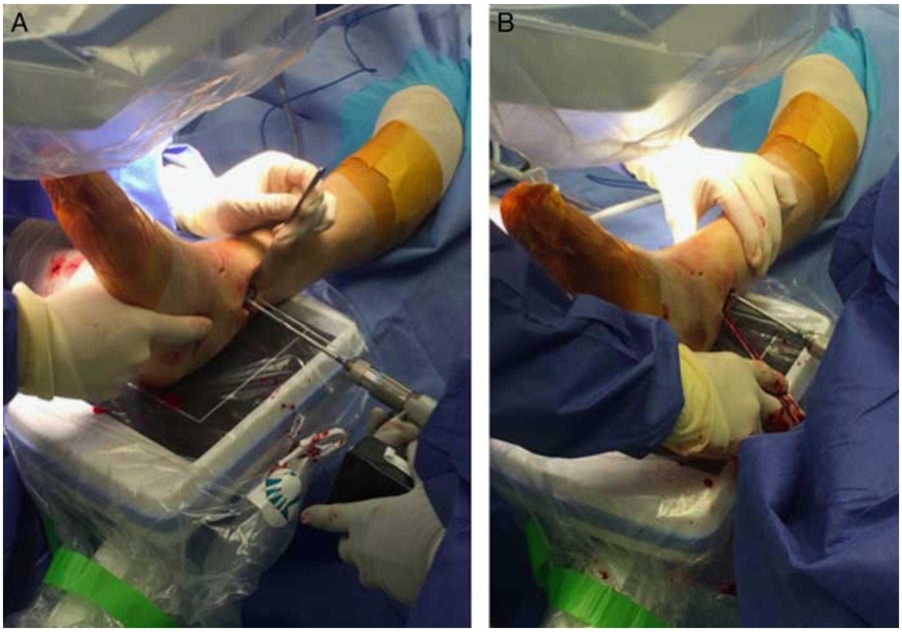

FIGURE 6. A and B, The first (A) and second (B) screw are placed by drilling across all 4 cortices.

the medial malleolus. An anchor with nonabsorbable sutures is placed at the medial malleolus (Fig. 8). A mattress-type suture pattern is conducted to repair the deltoid ligament and secure it back to the medial malleolus. The valgus tilt is assessed, to ensure it has been eliminated and a stable ankle is present.

Removal of Hardware

At approximately 3 months postoperatively or if a patient presents with painful hardware, the screws and plate are removed. A stress x-ray is performed in order to confirm stability as well as anatomic reduction. The patient is placed in a boot with protected weight-bearing for 2 weeks.

RESULTS

The senior author (M.C.D) has been using this screw fixation technique to fix unstable syndesmotic injuries since 2010. Since then, subjective results suggest a safe and effective method in

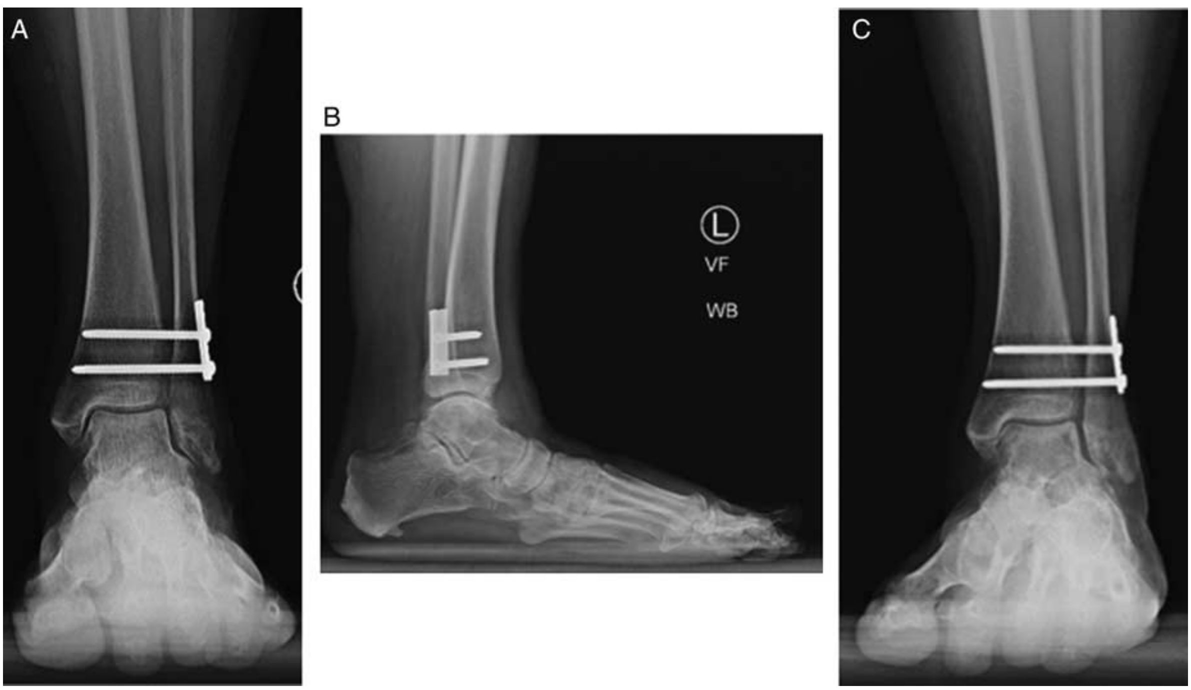

FIGURE 7. Postoperative anteroposterior (A), lateral (B), and oblique (C) x-ray photographs show the final structure of the screws and plate in the syndesmotic repair.

FIGURE 8. An anchor securing a deltoid ligament repair at the medial malleolus is indicated by the arrow.

treating patients with this injury. We have found the most success in patients who have the hardware removed at 3 months postoperatively. We have had no patients with late diastasis. This has limited the risk of hardware irritation and breakage sometimes associated with the screw fixation technique. We leave the screws slightly long so that they can be retrieved from the medial side in the case of breakage resulting in irritation.

Use of suture-button versus screws for fixation remains a source of debate in the current literature. Multiple studies suggest greater functional outcomes, quicker return to sport, and comparable postoperative reduction volume on computed tomography following repair with suture buttons.[32–34] However, several studies also point to greater success with the use of the screw fixation technique when reducing severely unstable injuries.[19–21] One specific study has reported a syndesmosis malreduction rate as high as 11% when elastic fixation was used.[35] Finally, multiple biomechanical analyses of fixation using a screw or suture-button construct indicated significantly increased fibular motion in the sagittal plane after repair with a single suture-button secured from the lateral fibula to the anterior medial malleolus in comparison with repair with a screw.[19,20] On the basis of this evidence, the screw fixation remains the preferred technique of the senior author for unstable syndesmotic ruptures with the primary rationale being the suture-button still allows supraphysiological motion of the fibula whereas screw fixation limits this motion.

Screw placement remains a highly debated topic in repairing the unstable syndesmosis. Contrasting biomechanical evidence exists with one source advocating placement at 2.0 cm, as opposed to 3.5 cm, above the tibiotalar joint to better prevent syndesmotic widening while another advocates placement 3.0 to 4.0 cm above the joint in order to minimize the resulting von Mise stress and potential damage to the tibiofibular articulation.[36,37] Ultimately, a balance must be struck with screws placed close enough to the joint to ensure proper fixation and avoidance of the negative effects on functional outcomes shown to be associated with placement above 41 mm, but high enough to avoid potential damage to the tibiofibular articulation.[38] Therefore, the senior author's decision has been to place the screws at the level of the physeal scar where damage to the tibiofibular articulation is minimized but fixation is great enough to hold alignment at the articular surface.

A determining factor of a successful syndesmotic repair is proper reduction of the injury as multiple studies connect malreductions with worse patient outcomes.[39–43] With multiple reduction techniques established in literature, there is little consensus about the optimal method. Results of a biomechanical analysis in cadaveric specimens show no reduction technique results in full restoration of preinjury tibial plafond contact mechanics.[21] However, use of a clamp or suture-button produced results suggestive of overreduction characterized by significant reductions in contact area and joint force.[21] Using the thumb technique to detect congruence and lack of steps or gaps in the anterior distal tibiofibular incisura and then securing the syndesmosis with a screw resulted in restoration of contact mechanics closest to that of an uninjured ankle.[21] For these reasons, the thumb technique is the preferred method of the senior author M.C.D during operative repair. This is the technique that has been described above, and the senior author has seen success and positive results. Finally, in another recent study, a retrospective review was performed on our ankle fracture patients treated between 2012 and 2016. Of the 116 consecutive patients identified and treated with ORIF and arthroscopy, 25 (22%) had complete syndesmosis disruption and instability.[31] Over half of these patients had their syndesmosis repaired using the screw fixation technique described. Preoperative and postoperative FAOS scores were analyzed and a statistically significant increase ($P \leq 0.01$) was seen in each FAOS subcategory with the average overall FAOS score increasing preoperatively to postoperatively from 26.31 to 85.23. Of these patients, 96% were found to have cartilage damage.[31] Thus, given the high association of cartilage findings, an arthroscopic approach proves beneficial.

Complications

The complications associated with the treatment of syndesmotic injuries include wound healing issues, infection, and potential nerve damage. Other complications associated with the screw fixation technique may be ankle stiffness, restricted fibular motion, hardware irritation, and malreduction. In the case of malreduction, a subsequent surgery may be necessary because, if left untreated, it can lead to worse long-term clinical outcomes.[42] Arthroscopic assessment of fibular reduction may lower the likelihood of malreduction in these cases but further study is needed.

Postoperative Management

Patients remain non–weight-bearing and follow-up 2 weeks after surgery for assessment of the wound and suture removal. At this time, the patient is transitioned into a removable, CAM walker boot if the wound has healed appropriately. The patient remains non–weight-bearing in the boot for 4 weeks and may slowly begin gentle range of motion activities. During this time, we recommend dorsiflexion and plantarflexion only with no internal or external rotation and no inversion or eversion. After this time, the patient may begin to partially apply weight with the boot as directed by a physical therapist for an additional 6 weeks. At 3 months postoperatively, the hardware is removed. The patient remains in a CAM walker boot for 2 weeks, full weight-bearing. There is some individual variability but the patient usually returns to full physical activity and sports in 4 to 5 months.

Future of the Technique

ORIF is a well-established treatment for unstable syndesmotic injuries. However, concerns of malreduction and the desire for minimally invasive techniques have led physicians to explore other interventions. The increased use of arthroscopy in foot and ankle procedures, and the potential to address all intra-articular pathology and confirm reductions may improve patient outcomes.[22,44] This intraoperative maneuver is extremely useful in detecting subtle ankle instability and ligamentous injury that may not be clearly present on radiographic imaging that does not indicate diastasis with a syndesmotic injury.[44] Furthermore, the use of suture-button technology may obviate the need for removal of hardware procedures; however, concerns remain with regard to the rigidity of the construct. Ultimately, anatomic reduction and addressing all pathology is required to effectively treat these injuries. As technology and our ability to effectively reduce injuries with smaller, less invasive devices improve, recovery from syndesmotic injuries should improve as well.

REFERENCES

1. Sikka RS, Fetzer GB, Sugarman E, et al. Correlating MRI findings with disability in syndesmotic sprains of NFL players. *Foot Ankle Int*. 2012;33:371–378.
2. Lin C-F, Gross ML, Weinhold P. Ankle syndesmosis injuries: anatomy, biomechanics, mechanism of injury, and clinical guidelines for diagnosis and intervention. *J Orthop Sports Phys Ther*. 2006;36:372–384.
3. Symeonidis PD, Iselin LD, Chehade M, et al. Common pitfalls in syndesmotic rupture management: a clinical audit. *Foot Ankle Int*. 2013;34:345–350.
4. Molinari A, Stolley M, Amendola A. High ankle sprains (syndesmotic) in athletes: diagnostic challenges and review of the literature. *Iowa Orthop J*. 2009;29:130–138.
5. Watson BC, Lucas DE, Simpson GA, et al. Arthroscopic evaluation of syndesmotic instability in a cadaveric model. *Foot Ankle Int*. 2015;36:1362–1368.
6. Gardner MJ, Demetrakopoulos D, Briggs SM, et al. Malreduction of the tibiofibular syndesmosis in ankle fractures. *Foot Ankle Int*. 2006;27:788–792.
7. Ebraheim NA, Lu J, Yang H, et al. Radiographic and CT evaluation of tibiofibular syndesmotic diastasis: a cadaver study. *Foot Ankle Int*. 1997;18:693–698.
8. Gerber JP, Williams GN, Scoville CR, et al. Persistent disability associated with ankle sprains: a prospective examination of an athletic population. *Foot Ankle Int*. 1998;19:653–660.
9. Porter DA, Jaggers RR, Barnes AF, et al. Optimal management of ankle syndesmosis injuries. *Open Access J Sports Med*. 2014;5:173–182.
10. Williams GN, Allen EJ. Rehabilitation of syndesmotic (high) ankle sprains. *Sports Health*. 2010;2:460–470.
11. Jelinek JA, Porter DA. Management of unstable ankle fractures and syndesmosis injuries in athletes. *Foot Ankle Clin*. 2009;14:277–298.
12. Vopat ML, Vopat BG, Lubberts B, et al. Current trends in the diagnosis and management of syndesmotic injury. *Curr Rev Musculoskelet Med*. 2017;10:94–103.
13. Hintermann B, Knupp M, Pagenstert GI. Deltoid ligament injuries: diagnosis and management. *Foot Ankle Clin*. 2006;11:625–637.
14. Stuart K, Panchbhavi VK. The fate of syndesmotic screws. *Foot Ankle Int*. 2011;32:S519–S525.
15. Zhang P, Liang Y, He J, et al. A systematic review of suture-button versus syndesmotic screw in the treatment of distal tibiofibular syndesmosis injury. *BMC Musculoskelet Disord*. 2017;18:286.
16. Kortekangas T, Savola O, Flinkkilä T, et al. A prospective randomised study comparing TightRope and syndesmotic screw fixation for accuracy and maintenance of syndesmotic reduction assessed with bilateral computed tomography. *Injury*. 2015;46:1119–1126.
17. Westermann RW, Rungprai C, Goetz JE, et al. The effect of suture-button fixation on simulated syndesmotic malreduction: a cadaveric study. *J Bone Joint Surg Am*. 2014;96:1732–1738.
18. Laflamme M, Belzile EL, Bédard L, et al. A prospective randomized multicenter trial comparing clinical outcomes of patients treated surgically with a static or dynamic implant for acute ankle syndesmosis rupture. *J Orthop Trauma*. 2015;29:216–223.
19. LaMothe JM, Baxter JR, Murphy C, et al. Three-dimensional analysis of fibular motion after fixation of syndesmotic injuries with a screw or suture-button construct. *Foot Ankle Int*. 2016;37:1350–1356.
20. Clanton TO, Whitlow SR, Williams BT, et al. Biomechanical comparison of 3 current ankle syndesmosis repair techniques. *Foot Ankle Int*. 2017;38:200–207.
21. LaMothe J, Baxter JR, Gilbert S, et al. Effect of complete syndesmotic disruption and deltoid injuries and different reduction methods on ankle joint contact mechanics. *Foot Ankle Int*. 2017;38:694–700.
22. Schairer WW, Nwachukwu BU, Dare DM, et al. Arthroscopically assisted open reduction-internal fixation of ankle fractures: significance of the arthroscopic ankle drive-through sign. *Arthrosc Tech*. 2016;5: e407–e412.
23. Ramsey PL, Hamilton W. Changes in tibiotalar area of contact caused by lateral talar shift. *J Bone*. 1976;58:356–357.
24. Laver L, Carmont MR, McConkey MO, et al. Plasma rich in growth factors (PRGF) as a treatment for high ankle sprain in elite athletes: a randomized control trial. *Knee Surg Sports Traumatol Arthrosc Off J ESSKA*. 2015;23:3383–3392.
25. Doughtie M. Syndesmotic ankle sprains in football: a survey of national football league athletic trainers. *J Athl Train*. 1999;34:15–18.
26. Drakos M, Birmingham P, Delos D, et al. Corticosteroid and anesthetic injections for muscle strains and ligament sprains in the NFL. *HSS J Musculoskelet J Hosp Spec Surg*. 2014;10:136–142.
27. Clanton TO, Paul P. Syndesmosis injuries in athletes. *Foot Ankle Clin*. 2002;7:529–549.
28. Amendola A, Williams G, Foster D. Evidence-based approach to treatment of acute traumatic syndesmosis (high ankle) sprains. *Sports Med Arthrosc Rev*. 2006;14:232–236.
29. LaMothe JM, Baxter JR, Karnovsky SC, et al. Syndesmotic injury assessment with lateral imaging during stress testing in a cadaveric model. *Foot Ankle Int*. 2018;39:479–484.
30. Sman AD, Hiller CE, Rae K, et al. Diagnostic accuracy of clinical tests for ankle syndesmosis injury. *Br J Sports Med*. 2015;49:323–329.
31. Da Cunha RJ, Karnovsky SC, Schairer W, et al. Ankle arthroscopy for diagnosis of full-thickness talar cartilage lesions in the setting of acute ankle fractures. *Arthroscopy*. 2018;34:1950–1957.
32. Andersen MR, Frihagen F, Hellund JC, et al. Randomized trial comparing suture button with single syndesmotic screw for syndesmosis injury. *J Bone Jt Surg*. 2018;100:2–12.
33. Colcuc C, Blank M, Stein T, et al. Lower complication rate and faster return to sports in patients with acute syndesmotic rupture treated with a new knotless suture button device. *Knee Surg Sports Traumatol Arthrosc*. 2017. Doi:10.1007/s00167-017-4820-3. [Epub ahead of print].
34. Schon JM, Williams BT, Venderley MB, et al. A 3-D CT analysis of screw and suture-button fixation of the syndesmosis. *Foot Ankle Int*. 2017;38:208–214.
35. Treon K, Beastall JE, Kumar K, et al. Complications of ankle syndesmosis stabilisation using a tightrope. *Orthop Proc*. 2011; 93-B (supp I):62–62.
36. Verim O, Er MS, Altinel L, et al. Biomechanical evaluation of syndesmotic screw position: a finite-element analysis. *J Orthop Trauma*. 2014;28:210–215.

37. McBryde A, Chiasson B, Wilhelm A, et al. Syndesmotic screw placement: a biomechanical analysis. *Foot Ankle Int*. 1997;18:262–266.
38. Schepers T, van der Linden H, van Lieshout EMM, et al. Technical aspects of the syndesmotic screw and their effect on functional outcome following acute distal tibiofibular syndesmosis injury. *Injury*. 2014;45:775–779.
39. Chissell HR, Jones J. The influence of a diastasis screw on the outcome of Weber type-C ankle fractures. *J Bone Joint Surg Br*. 1995;77:435–438.
40. Leeds HC, Ehrlich MG. Instability of the distal tibiofibular syndesmosis after bimalleolar and trimalleolar ankle fractures. *J Bone Joint Surg Am*. 1984;66:490–503.
41. Pettrone FA, Gail M, Pee D, et al. Quantitative criteria for prediction of the results after displaced fracture of the ankle. *J Bone Joint Surg Am*. 1983;65:667–677.
42. Sagi HC, Shah AR, Sanders RW. The functional consequence of syndesmotic joint malreduction at a minimum 2-year follow-up. *J Orthop Trauma*. 2012;26:439–443.
43. Weening B, Bhandari M. Predictors of functional outcome following transsyndesmotic screw fixation of ankle fractures. *J Orthop Trauma*. 2005;19:102–108.
44. Bonasia DE, Rossi R, Saltzman CL, et al. The role of arthroscopy in the management of fractures about the ankle. *J Am Acad Orthop Surg*. 2011;19:226–235.