CONTROVERSIAL ISSUES REGARDING THE SYNDESMOTIC SCREW

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BACKGROUND

The general consensus in the treatment of ankle fractures is that anatomic reduction and restoration of the distal tibiofibular relationship need to be achieved to obtain predictably good clinical results.[1,2] There are controversial issues that remain unsettled when discussing the optimal treatment of ankle fractures associated with trauma to the syndesmosis. These issues include indications for trans-syndesmotic fixation, proper anatomic level of syndesmotic screw placement and biomechanical effects on the ankle joint, the number of screws, and duration of fixation to allow healing of the syndesmosis. Many authors have warned of complications with screw fixation related to operative technique, mechanical failure of the screw or screws, and abnormal kinematics of the ankle joint.[3,4] Although current biomechanical and clinical data fail to answer most of these questions, they do allow the formulation of a rational approach to these controversial issues.

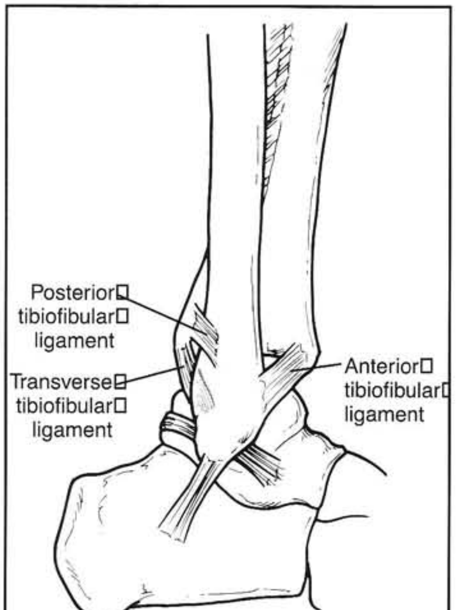

Figure 1. Anatomy of the inferior tibiofibular syndesmosis.

The distal tibiofibular syndesmosis is held together by the anterior-inferior and posterior-inferior tibiofibular ligaments, the deep transverse ligament, as well as the interosseous ligaments and interosseous membrane.(Fig. 1) These ligaments form a complex articulation that maintains the fibula closely approximated in the fibular notch.[5] Indications for repair of the syndesmosis remain controversial. The potential for synostosis and the need for an additional operative procedure for screw removal have been cited as reasons to avoid this type of fixation.[4] At the present time, syndesmotic screw fixation is recommended when there is a tibiofibular diastasis, a Maisonneuve fracture, or after internal fixation is performed and evidence of syndesmotic instability remains.[6] Leeds and Ehrlich found a significant correlation between the stability of the syndesmosis and a good clinical result.[7] Boden et al.[8] concluded from their study that the need for trans-syndesmotic fixation can be determined by the level of the fibular fracture. They also suggested that a fibular fracture above the "critical transition zone" or 3 to 4.5 cm proximal to the ankle joint required trans-syndesmotic fixation in order to decrease the incidence of post-traumatic osteoarthritis of the ankle.

The role of the syndesmosis and interosseous membrane in relation to the fibula function and ankle biomechanics has been addressed by numerous investigators. Vukicevic et al.[9] performed a study of the interosseous membrane and concluded that complete damage of the membrane decreased the load through the fibula by more than 30%. Skraba and Greenwald[10] used strain gauge measurements to show that the fibula stress decreased essentially to zero after incision of the membrane.

MECHANISM OF INJURY

Syndesmotic injuries can occur with or without an associated ankle fracture. Injury to the syndesmosis has been reported as a cause of recurrent ankle sprains, which are often associated with a prolonged recovery. In a large retrospective review of 1344

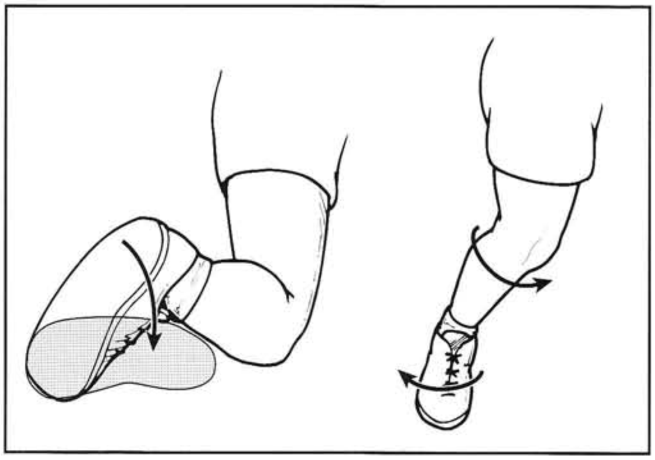

Figure 2. Mechanisms of distal tibiofibular syndesmotic injury.

ankle sprains, Hopkinson et al.[11] reported incidence of clinically detectable syndesmosis sprains or "high ankle" sprains of 1%; which were identified by a positive "squeeze" test. This is performed by squeezing the fibula toward the tibia above the midpoint of the calf. This test is positive if this maneuver produces pain in the ankle area. Hopkinson's study demonstrated that a positive squeeze test was associated with a longer recovery when similarly graded ankle sprains were compared. Syndesmotic injury with ankle diastasis without fibular fracture has been reported frequently.[12] Edwards and Lee[13] contributed a classification of ankle diastases without fibular fractures, which was described as "latent" or "frank." In case of "frank" diastasis, widening of the mortise is obvious on routine ankle radiographs. In "latent" cases, widening is only apparent with external rotation abduction stress.

The most common presentation of syndesmotic disruption occurs in the presence of an ankle fracture. The two most frequently used ankle fracture classifications are the Danis-Weber and Lauge-Hansen.[14] In the Lauge-Hansen classification, syndesmotic injuries can occur in stage II of pronation-abduction and pronation-external rotation injuries. (Fig. 2) However, Pankovich[15] suggested that from clinical and surgical observations, external rotation of a supinated foot could also produce a syndesmotic injury. The Danis-Weber classification is based on the level of the fibular fracture. Usually, the higher the fracture; i.e. Weber type C, the greater likelihood of instability due to increased extent of syndesmosis and interosseous membrane disruption. (Fig. 3)

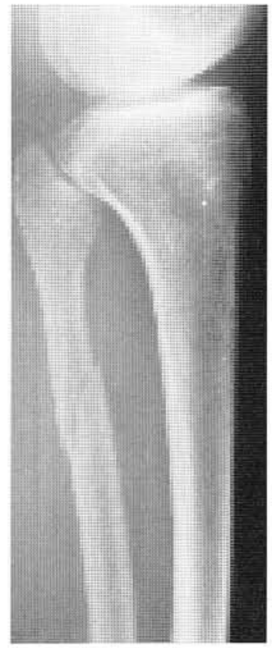

Figure 3. Maisonneuve fracture associated with Weber type C. Syndesmotic injury with an associated disruption of the interosseous membrane from the location of the fracture distally across the syndesmosis.

RADIOGRAPHIC ASSESSMENT

It is recommended that the stability of the syndesmosis should be assessed clinically and with radiographs before trans-syndesmotic fixation is instituted. The Cotton test may be used to assess syndesmosis instability.[16] It is performed by stabilizing the tibia and applying a lateral force to the foot, looking for any lateral translation of the foot, which would indicate syndesmotic instability.(Fig. 4) A diastasis may be produced with this maneuver and a stress radiograph in this position may be used to capture the instability. The "Hook" test can also be used to assess instability intra-operatively by grasping the distal fibula with a bone clamp attempting to distract the fibula from the tibia.[7] (Fig. 5)

Syndesmotic injuries may be difficult to appreciate by radiographic criteria because of the variation in the amount of rotation, the wide anatomic variability in the depth of the peroneal groove, and the shape of the tibial tubercle.[17] Harper and Kelly[18] performed a radiographic evaluation of cadaveric tibiofibular syndesmosis and concluded that the width of the "medial clear space" on both the AP and mortise views was the most reliable

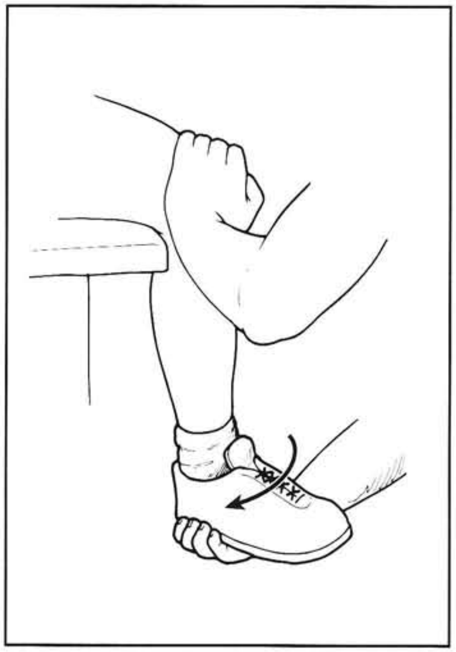

Figure 4. The Cotton Test is an external rotation stress test used to assess syndesmotic instability. The tibia is stabilized, while a lateral force is applied to the foot.

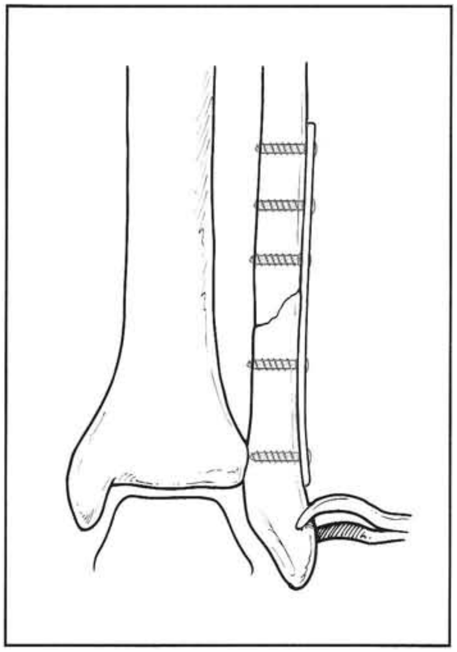

Figure 5. The Hook Test is performed intra-operatively to assess syndesmotic instability. A bone clamp is placed along the distal fibula and a laterally directed force is applied. If any lateral displacement of the fibula is possible, then a syndesmotic screw will be placed.

parameter for detecting widening of the syndesmosis. They determined that on AP radiographs, the normal clear space was 6mm or less and the normal tibiofibular overlap was greater than 6mm or 42% of the fibula width. (Fig. 6) Therefore, the clear space, measured 1cm above the ankle on a well-positioned AP and mortise radiographs, should be less than 6mm.[18] However, the mortise view of the ankle is very dependent on technique; therefore, measurements can be unreliable. Assessment of the disruption of the syndesmosis on stress lateral radiograph has a much higher correlation with anatomical diastasis than does that on a stress mortise radiograph.[5]

SCREW PLACEMENT

The AO manual of internal fixation states that syndesmotic fixation should be placed 2 to 3 cm proximal to the ankle joint. If the fixation is too low, it may pass through the distal tibiofibular articulation or through the tibiofibular ligaments, which can cause synostosis or calcification as well as chronic ankle pain, especially if the screw breaks within the tibiofibular joint. If the screw is placed too high, it may cause the fibula to toe outward.[19] Stabilization of

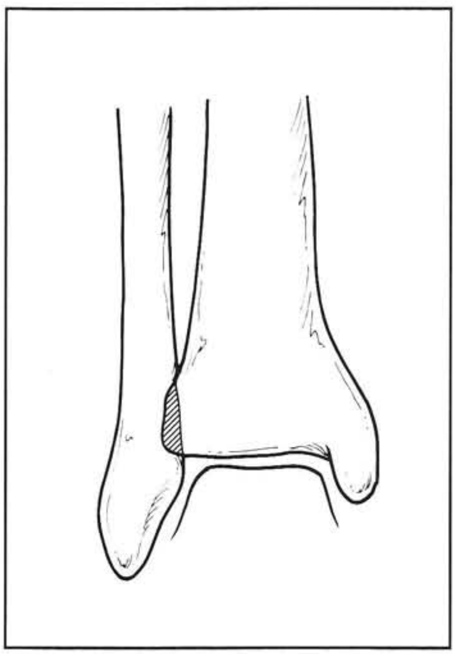

Figure 6. Measurements made on the AP radiograph of the ankle. Tibiofibular overlap (TFO) of less than 6mm may be associated with syndesmotic disruption.

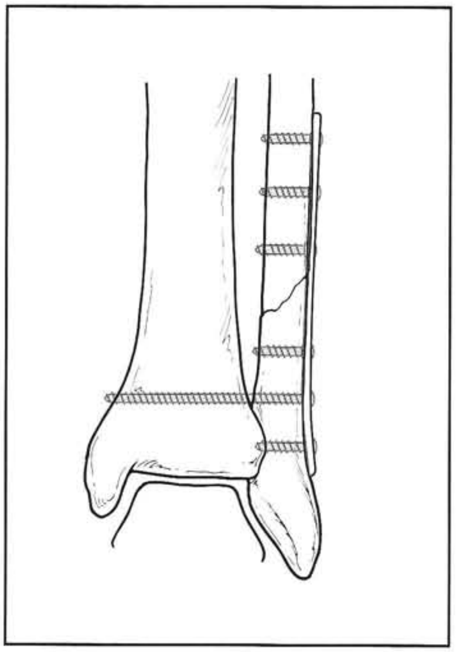

Figure 7. Syndesmotic screw placement 2 to 3 cm proximal to the ankle and parallel to the joint.

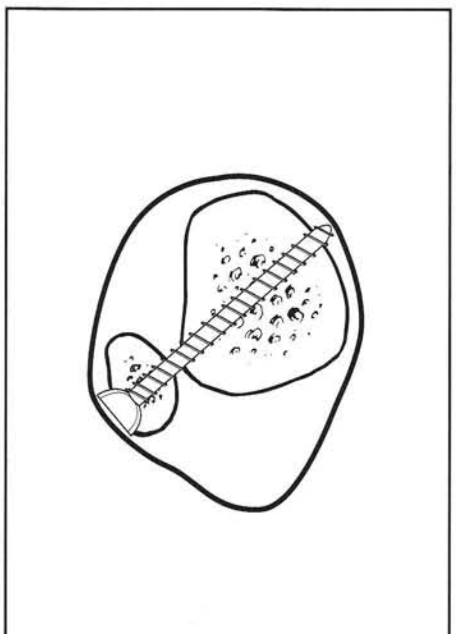

Figure 8. The syndesmotic screw must be angled 25 to 30 degrees aiming from posterolaterally to anteriomedially.

the syndesmosis may be achieved by placing one or two screws between the tibia and fibula to hold the syndesmosis in position until syndesmotic ligament healing occurs. The syndesmotic screw is also described as a positioning screw that is used to hold and not compress the syndesmosis.

The AO manual states that a 4.5mm or 3.5mm cortical screw is inserted through at least 3 cortices. It should be 2 to 3 cm proximal and parallel to the ankle joint.(Fig. 7) It should also be directed obliquely from back to front at an angle of 25 to 30 degrees starting posterolaterally and aiming antero-medially.[19] (Fig. 8) If the screw is not parallel to the ankle joint, it may cause the fibula to piston, which may shorten or lengthen the fibula. If the screw is not directed anteriorly, it may miss the tibia completely posteriorly. Screws up to 6.5mm in diameter have been used,[6] but the risk of fibular fracture exists with screws larger than 4.5mm. Kirschner wires have also been used to fixate the syndesmosis. They may be inserted obliquely across the distal fibular syndesmosis. They are a less rigid form of fixation, which allows more physiologic ankle fixation and does not require early hardware removal.[5]

Mulligan and Hopkinson's work in 1995 demonstrated that repair with two trans-syndesmotic screws inserted through three cortices provided significantly more stability than one screw engaging all four cortices. They also explained that if a screw engages only three cortices, normal external rotation of the fibula during ankle dorsiflexion would not be affected. If movement occurs, the screw will loosen in the lateral cortex of the tibia rather than break. However, screw engagement in the far cortex may risk screw breakage.[5] It is important to inform patients that hardware failure, such as screw breakage is a common complication and does not necessarily imply that there was a surgical error.

During screw placement it is recommended that the foot be positioned in a dorsiflexed attitude to ensure that the widest area of the talus is within the ankle mortise, thereby decreasing the risk of stiffness.[20] Generally 5 degrees of dorsiflexion is sufficient; more dorsiflexion might cause excessive widening of the mortise leading to instability. Olerud's study showed that ankle joint dorsiflexion decreased by an average of 0.1 degrees for every one degree increase in plantarflexion when the screw was being inserted.[20]

SCREW REMOVAL

Controversy continues to exist whether or not to remove the screws prior to full activity or ambulation. Many authors recommend removing the screws prior to full weightbearing, since the syndesmotic screw tends to limit ankle joint range of motion; which could potentially transfer weightbearing forces against the screw, leading to breakage.[21] Generally, syndesmotic screws are removed anytime between 6 to 12 weeks, but there has been some interest in waiting up to 4 months to avoid late syndesmotic widening. Needleman et al.[21] looked at effects of syndesmotic screws on ankle joint motion in cadaveric ankles. They inserted the screws using AO technique and concluded from their findings of restricted ankle rotation and changes in normal ligament length/tension relationship that the screw should be removed prior to full activity.

Kaye[6] noted bony erosions around the screw prior to removal in 20 of 30 patients treated after syndesmotic trauma. He felt that this reflected gradual re-establishment of motion between distal tibia and fibula. De Souza et al.[22] used syndesmotic screws in 30 Maisonneuve or Danis-Weber type C fractures. Full weightbearing was allowed at 4 weeks in a cast and 8 weeks without a cast. In 18 out of 30 patients screws were removed at approximately 1 year and the remainder were left for greater than 2 years. They concluded that full weightbearing is permitted and no untoward results were noted leaving the screws in place. Fibular motion has been shown to occur in the lateral and posterior direction, as well as in the vertical axis and in rotation.[17] The fibula migrates distally secondary to contraction of the foot flexors during stance or propulsion an average of 2.4mm.[8] As a result, the ankle joint is deepened and provides more stability to the ankle during stress. From this data, it appears that if normal fibular motion is altered i.e. use of trans-syndesmotic screws, ankle function may also be compromised. Based on the biomechanical and clinical data and despite De Souza's study, many continue to feel that syndesmotic screws should be removed prior to full weightbearing and activity to allow normal ankle function.

BIOABSORBABLE SCREWS

Over the past decade, implants fabricated from absorbable alpha-hydroxy polyesters have been used in multiple orthopedic applications including ankle fractures. Over the past couple of years polylactide acid (PLA) screws have been utilized for ankle fractures associated with syndesmotic injuries. Advocates of this type of fixation claim that the traditional method of using metallic screws across the syndesmosis is associated with frequent complications including screw loosening or breakage.[23] This complication is attributable to fatigue failure from cyclic loading from normal motion between the distal fibula and tibia during ambulation. Loose or broken screws are often very painful. Advocates claim that the use of bioabsorbable screws for syndesmotic injuries should permit healing of the disrupted syndesmotic ligaments and prevent the clinically evident complications of screw loosening and breakage.[23] With degradation and absorption, there should be no need for screw removal.

The primary advantages of absorbable implants include radiolucency, minimal osteolysis surrounding the screws associated with stress shielding and osteopenia, gradual transfer of load from the implant to the healing bone, minimized disruption of the normal ankle biomechanics, and obviously the elimination of subsequent procedures for implant removal and additional costs.[23] While the track of the implant in cortical or cancellous bone is radiographically evident, the resorbable implants do not obscure the surrounding bone, thus facilitating the postoperative radiographic assessment of fracture healing. (Fig. 9) Through hydrolysis of the polyester, the strength and stiffness of the implant are slowly diminished. Complete resorption of the implant requires several months to 5 or more years depending on multiple factors, including crystalinity, chemical composition, and size. PLA screws maintain their tensile strength for the longest duration when compared to polyglycolic acid (PGA) or polyparadioxanone (PDS).[23] PLA screws maintain approximately 80% of their original tensile strength at 4 weeks and 50% at 12 weeks after implantation. The polymers in the PLA screws are oriented in a parallel fashion, increasing their tensile strength and making them ideal for treatment of the syndesmosis.

The disadvantages of bioabsorbable implants include both mechanical and biologic. The ultimate tensile and torsional strengths of these screws are

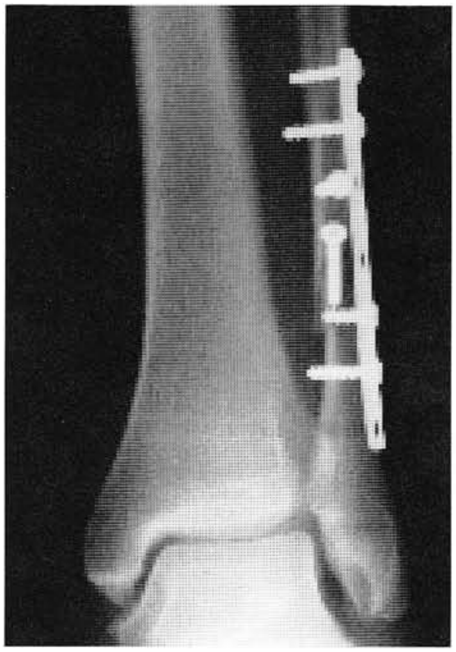

Figure 9. Absorbable trans-syndesmotic screw placed after a PER IV ankle fracture. Notice track of the implant.

significantly lower than their metallic counterparts. Thoradson has evaluated the use of a PLA screw in a cadaveric model for syndesmotic repair and found it to have adequate strength to allow for syndesmotic healing when subjected to the same stresses that a stainless steel screw endures before removal.[24] Additionally, certain polyesters, most notably PGA, have been associated with a local inflammatory response often leading to a sterile abscess.[23] Such inflammatory reactions have not been evidenced with the more hydrophobic polyesters such as PLA.

If an absorbable syndesmotic screw is inserted, it is placed in the same manner as a stainless steel syndesmotic screw. Because of the mechanical demands of the syndesmosis, 4.5mm PLA screws are preferred (Bionx Smart Screw). A 3.5mm hole is drilled through both cortices of the tibia and fibula. Drilling of only the lateral cortex of the tibia will result in inadequate fixation.[23] The full length of the drill hole is tapped with a 4.5mm tap. The full depth of the drill hole is measured with a depth gauge and an appropriate length 4.5mm screw is inserted which is usually approximately 40mm long fully-threaded screw. The syndesmotic screw may also be inserted through a tubular plate, in which case a 3.5mm screw is used.[25]

CONCLUSION

Ankle fractures associated with injury to the syndesmosis should be evaluated carefully. The ultimate goal is restoration of the distal tibiofibular relationship and anatomical reduction of the ankle joint to decrease the incidence of post-traumatic osteoarthritis of the ankle. Multiple controversies continue to exist with regard to trans-syndesmotic screw fixation for unstable syndesmotic injuries. The advent of absorbable implants and their use in syndesmotic injuries has shown some predictably good clinical results. Although their tensile and torsional strengths are less than traditional metallic screws, there are multiple advantages with their utilization. More research and long-term follow up are needed to confirm which type of fixation is best.

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