Current Concepts Review: Operative Techniques for Stabilizing the Distal Tibiofibular Syndesmosis

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INTRODUCTION

The distal tibiofibular syndesmosis is essential for the stability of the ankle joint that is required for weight transmission and walking.¹⁻⁴² The syndesmosis consists of the anterior-inferior tibiofibular ligament, posterior-inferior tibiofibular ligament, inferior transverse tibiofibular ligament, and interosseous ligament. This complex stabilizes the mortise by securing the fibula in the fibular notch (incisura fibularis tibiae).

Syndesmotic injuries most commonly are caused by pronation-external rotation, pronation-abduction and, less frequently, a supination-external rotation mechanism (Danis-Weber C injuries).³¹ These forces cause the talus to abduct or to rotate externally in the mortise, leading to disruption of the syndesmotic ligaments.³¹,⁵⁵ Anatomical restoration of the disrupted distal tibiofibular syndesmosis is essential.⁵⁴ Widening and chronic instability of the distal tibiofibular syndesmosis have been correlated with poor functional outcomes and the development of osteoarthritis.¹¹,¹⁶,⁴¹,⁴⁴,⁵² Because nonoperative treatment cannot effectively stabilize the distal tibiofibular syndesmosis during healing, operative fixation often is recommended. However, the need for trans-syndesmotic fixation of the distal tibiofibular joint is controversial, and recommendations for fixation for specific ankle injury patterns are conflicting.⁶ Other areas of controversy include the optimal number of cortices, the appropriate size of the screws, the position of the ankle joint during screw insertion, the use of one or two screws, the position of the screw(s) relative to the tibiotalar joint when weightbearing is allowed, and the need for and timing of implant removal.

Numerous operative techniques have been described for stabilizing the distal tibiofibular syndesmosis; the objective of this article was to review the literature concerning these procedures to determine if recommendations could be made for clinical practice.

ARTICLE SELECTION

The search of the literature was limited to published original studies that included patients with a diagnosis of syndesmosis injury made on the basis of detailed clinical, radiographic, or intraoperative findings who had stabilization of the distal tibiofibular syndesmosis by any operative method. The main databases (Medline, Cochrane Database of Systematic Reviews, Cochrane Clinical Trial Register,
Database of Abstracts on Reviews and Effectiveness, Current Controlled Trials, National Research Register and Embase) were searched from 1988, to October 2006, to identify relevant studies. Furthermore, the lists of references of retrieved publications were manually checked for additional studies that might meet the inclusion criteria. The search was restricted to articles written in the English. Abstracts from scientific meetings were excluded. Initially, we intended to use a strict methodology for paper selection, focusing on objectively measurable variables, separate evaluation of different pathologies (syndesmotic injury with and without a fracture), and randomized controlled trials. However, few of the available papers fulfilled these criteria. Different inclusion criteria among the reports (different indications for syndesmotic fixation, different postoperative weightbearing protocols, and device removal at different times) prohibited a statistical evaluation and comparison of different techniques. Most of the reports represented Level IV or V evidence (Tables 1 and 2).

**OPERATIVE PROCEDURES FOR SYNDESMOSIS STABILIZATION**

Stabilization of a disrupted syndesmosis can be obtained by repairing ruptured ligaments and by fixing associated fractures of the fibula, avulsed tubercles, and medial malleolus. In addition to conventional syndesmotic screw fixation, stabilization techniques include the use of bioabsorbable screws, syndesmotic staples, circular wire external fixators, Kirschner wires, flexible implants, syndesmotic hooks, syndesmotic bolts, and cerclage wires, as well as ligamentoplasties between the tibia and fibula to hold the syndesmosis in position until fibrotic replacement or some degree of syndesmotic ligament healing can occur. The ideal implant to stabilize syndesmosis disruption should be strong enough to resist diastasis and allow early mobilization, yet still allow physiologic micromotion. Routine removal should not be required, but the implant should be easily removable if necessary, such as in the event of infection. The implant should remain intact until full ligament healing is ensured to prevent late diastasis, and it should be easily inserted with minimal operative trauma.

**BIOABSORBABLE SYNDESMOMATIC SCREW**

Metal screws have traditionally been used for syndesmosis fixation, but removal is necessary, and broken or loose screws can cause problems. As an alternative, bioabsorbable screws have been suggested by several authors. Thordarson et al. and Cox et al. compared repair with stainless steel screws to repair with bioabsorbable screws in simulated syndesmosis injuries in cadaver specimens. Thordarson et al. reported no differences in load to failure or stiffness, and none of the screws broke or failed. No significant screw damage was evident on radiographic or CT evaluation. Cox et al. reported that failure torque and angle of rotation at failure were nearly equivalent with metal and bioabsorbable screws.

Three studies without a control group (Level IV evidence) reported their results with bioabsorbable syndesmotic screws. Korkala et al. treated seven patients with malleolar fractures and syndesmotic separations with plate-and-screw fixation of the fractures and repair of the syndesmosis with one or two bioabsorbable screws. Although the one patient who had bioabsorbable screws developed transient sinus formation and intraosseous osteolysis, all patients had acceptable results with a stable ankle mortise. More recently, Miller and Carls reported their results of syndesmotic fixation with 5-mm bioabsorbable screws in four patients. Healing was uneventful, with anatomic maintenance of the syndesmosis and no radiographic evidence of osteolysis at the screw sites. Hovis et al. reported 23 fractured ankles with syndesmotic disruption stabilized with 4.5-mm four-cortical bioabsorbable screws. All malleolar fractures healed in an anatomical position in an average of 3 months, and no postoperative displacement of the syndesmosis or widening of the medial clear space was detectable on radiographs. No osteolysis or late inflammation secondary to the screw occurred. Nineteen patients had excellent results, and four patients had good results. All 23 patients returned to their pre-injury levels of work and activities of daily living. No patient had malunion, nonunion, loss of reduction, or complications attributable to the biomechanical or biochemical properties of the implants.

**Table 1: Level of evidence and grades of recommendation**

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Grades of Recommendation</th>
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<tbody>
<tr>
<td>Level I: high quality prospective randomized clinical trial</td>
<td>Grade A treatment options are supported by strong evidence (consistent with Level I or II studies)</td>
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<tr>
<td>Level II: prospective comparative study</td>
<td>Grade B treatment options are supported by fair evidence (consistent with Level III or IV studies)</td>
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<td>Level III: retrospective case control study</td>
<td>Grade C treatment options are supported by either conflicting or poor quality evidence (Level IV studies)</td>
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<td>Level IV: case series</td>
<td>Grade I when insufficient evidence exists to make a recommendation</td>
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<td>Level V: expert opinion</td>
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<td>— Level V: expert opinion</td>
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30, 36, 48, 49
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<tr>
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<th>Year</th>
<th>Country</th>
<th>Patients</th>
<th>Follow-up</th>
<th>Device</th>
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<tbody>
<tr>
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<td>2005</td>
<td>U.S.</td>
<td>8</td>
<td>Cadaver</td>
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<td>7</td>
<td>12-18</td>
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<td>IV</td>
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<td>U.S.</td>
<td>4</td>
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<td>23</td>
<td>34</td>
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<td>IV</td>
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<td>Finland</td>
<td>18</td>
<td>12</td>
<td>Bioabsorbable versus metallic screw</td>
<td>II</td>
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<td>Thodarson et al.</td>
<td>1997</td>
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<td>6</td>
<td>Cadaver</td>
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<td>U.S.</td>
<td>17</td>
<td>3</td>
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<td>I</td>
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<td>2005</td>
<td>Finland</td>
<td>20</td>
<td>35</td>
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<td>I</td>
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<td>Sweden</td>
<td>48</td>
<td>NM</td>
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<td>IV</td>
</tr>
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<td>Yde et al.</td>
<td>1981</td>
<td>Denmark</td>
<td>16</td>
<td>71</td>
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<td>IV</td>
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<td>2005</td>
<td>U.S.</td>
<td>21</td>
<td>Cadaver</td>
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<td>N.C.</td>
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<tr>
<td>ElRayes et al.</td>
<td>2006</td>
<td>Kuwait</td>
<td>38</td>
<td>35</td>
<td>Syndesmotic staple versus syndesmotic screw</td>
<td>III</td>
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<td>2001</td>
<td>U.K.</td>
<td>1</td>
<td>36</td>
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<td>V</td>
</tr>
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<td>1994</td>
<td>U.S.</td>
<td>8</td>
<td>Cadaver</td>
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<td>8</td>
<td>Cadaver</td>
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<td>12</td>
<td>24-48/Cadaver</td>
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<td>II</td>
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<td>U.S.</td>
<td>13</td>
<td>Cadaver</td>
<td>Suture construct versus syndesmotic screw</td>
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<td>1985</td>
<td>U.K.</td>
<td>6</td>
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<td>1995</td>
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<td>2</td>
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<td>IV</td>
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<td>1999</td>
<td>Turkey</td>
<td>128</td>
<td>37</td>
<td>ANK nail</td>
<td>IV</td>
</tr>
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<td>2000</td>
<td>Turkey</td>
<td>49</td>
<td>41</td>
<td>ANK nail</td>
<td>IV</td>
</tr>
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<td>1942</td>
<td>U.K.</td>
<td>NM</td>
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<td>V</td>
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<td>U.S.</td>
<td>NM</td>
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<td>Netherlands</td>
<td>9</td>
<td>45</td>
<td>Translation osteotomy of AITFL insertion</td>
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NM, not mentioned; L of E, level of evidence; NC, not a clinical study; AITFL, anterior inferior tibiofibular ligament; Follow-up (in months).
SYNDESMOTIC STAPLE

Three level I or II studies have compared bioabsorbable screws with traditional metallic screw fixation. Sinisaaari et al.\(^\text{46}\) (Level II) compared the results of 18 patients treated with bioabsorbable screws to those of 12 patients treated with metallic screws. At a minimum followup of 12 months, there were no significant differences in ankle range of motion, in duration of sick leave, or in subjective results. In a prospective, randomized trial (Level I) Thordarson et al.\(^\text{49}\) compared syndesmosis fixation with 4.5-mm stainless steel screws (17 patients) to fixation with 4.5-mm bioabsorbable screws (15 patients) in patients with pronation-external rotation fractures. All patients had uncomplicated healing of their fibular fractures without loss of reduction or wound complications. There was no difference in range of motion or subjective complaints between the two groups, and no evidence of osteolysis or sterile effusion was noted in the absorbable screw group. Kaukonen et al.\(^\text{28}\) in a randomized prospective study (Level 1) of 38 consecutive patients with clinically verified syndesmotic ruptures and malleolar fractures, compared metal screw fixation in 18 to bioabsorbable screw fixation in 20. More patients with bioabsorbable screws returned to their previous activity levels than did patients with metal screws, and they had less ankle swelling than patients with metal screws, but joint motion was similar between the groups.

SYNDESMOTIC STAPLE

Early advocates of the syndesmotic staple were Cedell and Wiberg,\(^\text{8}\) who reported its use in 48 patients with fibular fractures and anterior tibiofibular ligament ruptures (Level IV). The metal staple was inserted between the distal ends of the fibula and the tibia at sites corresponding to the insertion and origin of the anterior tibiofibular ligament. No operative complications occurred, and the results were primarily good in all patients. Marqueen et al.\(^\text{35}\) compared the stability, durability, and mechanical strength of barbed round syndesmotic staples to those of 4.5-mm cortical syndesmotic screws in 21 cadaver specimens. Both provided similar performance in load-to-failure testing, while the screw reduced tibial rotation more after cyclic loading. There was more tibial rotation before failure with the staple, suggesting a more elastic construct. Yde and Kristensen\(^\text{56}\) retrospectively studied 16 patients with stage 3 or 4 pronation-external rotation fractures who had fixation of the fibular and medial malleolar fractures and of the deltoid ligament ruptures (Level IV). The anterior tibiofibular ligament was repaired or, if an avulsion was present, fixed with a pin or perioseal suture. After manual compression, the staple was hammered across the syndesmosis parallel to the ligament between the anterior tibial tubercle and the lateral malleolus. At an average followup of 5.9 years, all patients had good results and were either pain-free or had minimal symptoms, with no radiographic evidence of mortise widening or staple dislocation. One patient had a broken staple that occurred after full weightbearing began. Kelikian and Kelikian\(^\text{29}\) advocated the syndesmotic staple for acute injuries and for reconstructive indications (Level V). They described a technique in which a long extensor ligament is harvested for reconstruction of the anterior tibiofibular ligament in addition to use of the staple. Elrayes and Hammoda\(^\text{12}\) compared syndesmotic screws to staples for stabilization of inferior tibiofibular syndesmotic diastasis in 76 patients with unstable ankle fractures (Level III). More than 5 mm of widening of the medial joint space seen in the anteroposterior view was their indication for syndesmosis fixation. The syndesmotic diastasis was stabilized with a screw in 38 patients (1st group) or a staple in 38 patients (2nd group). The fractured fibula was anatomically reduced and internally fixed and reduced in the syndesmotic groove, and the syndesmosis was stabilized with a screw (38 patients) or staple (38 patients). A below-the-knee cast was worn for 2 weeks, then active mobilization of the joint was started. Full weightbearing was allowed when union was established. After a mean followup of 34.8 (range 24 to 48) months, no recurrence of diastasis was detected in either group; chronic pain in the region of the syndesmosis was present in 65% of patients with screw fixation compared to 5% in those with staple fixation. Heterotropic ossification was found in the region of the syndesmosis in 50% of patients with screw fixation and in 5% of those with staple fixation. Tibiofibular synostosis occurred at the site of the screw in one patient; one screw and one staple broke.

ILIZAROV RING FIXATOR

Relwani et al.\(^\text{43}\) described one patient with a disrupted inferior tibiofibular syndesmosis without fibular fracture (Level V). A tricortical 4.5-mm syndesmotic screw was placed, but because of his excessive body weight the patient was unable to comply with the nonweightbearing regimen. At 6-week followup the screw had backed out and the syndesmosis had again widened. The screw was removed, the syndesmosis was reduced and held with an Ilizarov external fixator, and weightbearing to tolerance was allowed. The frame was removed at 12 weeks. At 3-year followup the mortise remained reduced, and the patient was asymptomatic with a full range of motion of the ankle.

KIRSCHNER WIRES

In a cadaver study, Peter et al.\(^\text{40}\) compared fixation of the distal tibiofibular syndesmosis in Weber C ankle fractures with either a 3.5-mm transverse suprasynodesmotic neutralization screw or with two obliquely oriented transsynodesmotic 1.5-mm Kirschner wires after fixation of the fibular fractures with a one-third tubular plate. Both techniques stabilized the syndesmosis and limited its normal motion during flexion and dorsiflexion of the ankle, but both also altered ankle biomechanics by shifting load transmission laterally compared with the uninjured joint.
FLEXIBLE FIXATION CONSTRUCTS

Because rigid fixation inhibits the normal flexibility of the syndesmosis and ankle joint, the use of flexible suture constructs have been advocated. Seitz et al.\textsuperscript{45} tested the pull-out strength of a flexible suture-and-button construct to that of a tricortical syndesmotic screw in 10 paired cadaver ankles. The flexible implant had a suture tensile strength of 60 lbs and consistent suture strength of 49 lbs; tricortical screw fixation had a pull-out strength of 82 lbs, but demonstrated a wide variability depending on bone quality. In a clinical review (Level IV) of the flexible implant, 12 patients had healing without radiographic deformity or clinical instability. Analysis of devices removed 8 to 12 months after implantation showed that all remained intact without failure. Miller et al.\textsuperscript{37} compared tricortical screw fixation to a suture construct without supporting buttons for fixation of ankle syndesmosis injuries in 26 cadaver specimens. Two strands of No. 5 polyester braided suture were passed through holes drilled through the fibula and tibia and tied at the lateral malleolus. A 3.5-mm tricortical screw was placed on the opposite leg of each pair. There was no significant difference in strength or displacement between the flexible suture fixation and the tricortical screw at either 20 mm or 50 mm above the tibial plafond, although with both types of fixation holding strength was significantly greater and displacement was significantly less with fixation at 50 mm than at 20 mm.

Thornes et al.\textsuperscript{51} compared a suture-Endobutton (Acufex, Smith & Nephew, Mansfield, MA) construct to standard 4.5-mm syndesmosis screw fixation in 16 cadavers with simulated syndesmosis injuries and found no significant difference in the mean rate of failure between Endobutton and screw fixation or between fixation placement at 20 mm or 50 mm above the tibial plafond. There were no implant failures. In a prospective clinical study (Level III), Thornes et al.\textsuperscript{50} also reported the outcomes of suture-button fixation in 16 patients. At both 3-month and 12-month followups, the mean American Orthopaedic Foot and Ankle Society ankle scores were significantly better in patients who had suture-button fixation than in a comparative group of patients who had syndesmosis screw fixation. The period of nonweightbearing was shorter and return to work was faster in patients who had suture-button fixation, and none of the patients who had suture-buttons required a second surgery for implant removal, while 12 of the 16 with screw fixation required implant removal.

SYNDESMOSIS HOOK

The syndesmosis hook, first described by Engelbrecht\textsuperscript{13,14} in the German literature and by Farhan and Smith\textsuperscript{15} in the English literature, is another device purported to allow more physiologic motion at the syndesmosis. The hook is a stainless-steel semi-circle that passes round the fibula above the level of the syndesmosis and is secured to the tibia by a single cancellous bone screw passed through the eye of the hook. Farhan and Smith\textsuperscript{15} described the use of the syndesmosis hook in six patients who had ankle fractures with diastasis of the inferior tibiofibular joint (Level IV). Four patients required internal fixation of fractures of the distal fibula and two required fixation of the medial malleolus. The authors reported no difficulty in passing the hook around the one-third tubular plates used for fixation of the fibular fractures. Early weight-bearing was encouraged and the length of cast immobilization (range 2 to 12 weeks) was based on pain and tenderness. Clinically, four patients had good results and two had fair results (9 and 12 weeks of immobilization). Radiographic results were good in all six, with no evidence of arthritis or synostosis in any patient.

TRANS-SYNDENOSMOTIC BOLT

Grady et al.\textsuperscript{18} described the use of a trans-syndesmotic bolt in two patients (Level IV) with good results, no complications, and return to full activity. The self-tapping bolt was passed through the fibula and tibia and the diastasis was compressed by tightening of a nut on the medial side. Postoperative immobilization included 4 weeks in a nonweightbearing cast and 4 weeks in a weightbearing cast.

ANK NAIL

The ANK nail was developed by Ayhan Nedim Kara (ANK) in 1982,\textsuperscript{25,26} for treatment of fractures of the lateral malleolus associated with syndesmotic ruptures; it is not recommended for comminuted or otherwise unstable fractures.\textsuperscript{24,26} The cited advantage of the ANK nail is that it simultaneously provides fixation of the malleolar fracture and stabilizes the syndesmosis ligamentous injury. By allowing physiologic loading of the ankle, it acts as an “artificial syndesmosis” during healing.\textsuperscript{26} The ANK device consists of a thin (2.5-mm) stainless steel fibular intramedullary nail with a hole at its distal end for fixation of a screw to the tibia. Kara et al.\textsuperscript{26} retrospectively reviewed the results of this device in 128 patients (Level IV) at a mean follow-up of 3.1 years: 93 patients (73%) had good objective results, 28 had fair results, and seven had poor objective results. Subjectively, 94 (73%) had good results, 26 had fair results, and eight had poor results. Radiographic results were good in 99 patients (77%), fair in 21, and poor in eight. The most common problem noted by these authors was fibular shortening, which occurred in 11 (9%) of the 128 patients: all 11 had comminuted or oblique lateral malleolar fractures. Kabukcuoglu et al.\textsuperscript{24} reported 84% excellent or good results in 49 patients at an average 42-month followup after syndesmosis fixation with the ANK device: 29 excellent results, 12 good results, five fair results,
and three poor results. Arthrosis was observed in three patients.

CERCLAGE WIRE

Transosseous cerclage wire fixation of the syndesmosis was originally described by Burns and later by Fusii and Pagani and Ronco in the Italian literature (Level V). The success rate of this fixation method is unknown.

LIGAMENTOPLASTIES

Because ligamentous support has been shown to play a large part in the stability of the syndesmosis joint, some authors have suggested that ligament repair should be included in the treatment of both acute and chronic syndesmotic injuries. In 16 of a group of 87 patients with separation of the distal tibiofibular syndesmosis, Bai et al. used the peroneus longus tendon for repair of the distal tibiofibular ligaments with the peroneus longus tendon, combined with reduction of the separated distal tibiofibular and fixation with cancellous screws. All 16 patients had good results without separation of the syndesmosis after screw removal (Level IV). Grass et al. described a ligamentoplasty with a split peroneus longus tendon graft in 16 patients with chronic syndesmotic insufficiency (Level IV). At a mean followup of 16 months, 15 of the 16 patients had relief of pain, swelling, and giving way. Beumer et al. described an anatomic reconstruction of the anterior tibiofibular ligament with a bone-block technique in nine patients with chronic instability (Level IV). At a mean followup of 45 months, all considered the ankle to be improved, and none complained of instability. Transient sympathetic reflex dystrophy occurred in two patients and entrapment of the intermediate dorsal cutaneous nerve in scar tissue in one.

DISCUSSION

Although there are few Level I or II studies on which to base recommendations, some observations are possible.

- Traditional metal screw fixation continues to be a popular option, with good results reported by several studies, although a disadvantage is the necessity for a second operative procedure for screw removal.
- Bioabsorbable screws have been shown to have results equal to those of metal screws, without the need for screw removal.
- The few studies describing syndesmotic fixation with a staple reported accurate and anatomic positioning of the fibula and accommodation of the small amount of physiologic movement that occurs in the syndesmosis, making it compatible with early functional movement.

- Thin-wire circular external fixators and cerclage wires have been used for fixation of the syndesmosis, but there are no patient series to support this (Grade D).
- A single study reported that two Kirschner-wires stabilized the syndesmotic joint as well as traditional syndesmotic screws; both limited normal motion during flexion and dorsiflexion of the ankle.
- Biomechanical and clinical studies showed good outcomes with flexible suture fixation, which allow physiologic motion of the syndesmosis joint. The syndesmosis hook, syndesmotic bolt, and ANK nail were all reported to give moderately good results, but these techniques were not compared to fixation with a syndesmosis screw.
- Because of the scarcity of reports, the efficacy of ligamentoplasty with the extensor tendon of the fourth toe or the peroneus longus tendon or translation osteotomy could not be determined.

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