

[Imaging]

Magnetic Resonance Imaging as a Predictor of Return to Play Following Syndesmosis (High) Ankle Sprains in Professional Football Players

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Background: Syndesmosis ankle sprains cause greater disability and longer duration of recovery than lateral ankle sprains.

Objective: To describe the severity of syndesmosis sprains using several accepted magnetic resonance imaging (MRI) criteria and to assess the interrater reliability of diagnosing syndesmosis injury using these same criteria in professional American football players.

Hypothesis: There is a high degree of interrater reliability of MRI findings in American football players with syndesmosis ankle sprains. These radiographic findings will correlate with time lost to injury, indicating severity of the sprain.

Study Design: Uncontrolled retrospective review.

Methods: Player demographics and time lost to play were recorded among professional football players who had sustained a syndesmosis ankle sprain and underwent standardized ankle MRI. Each image was independently read by 3 blinded musculoskeletal radiologists.

Results: Seventeen players met study criteria. There was almost perfect agreement among the radiologists for diagnosing injury to the syndesmotomembrane; substantial agreement for diagnosing injury to the posterior inferior tibiofibular ligament (PITFL) and in determining the proximal extent of syndesmotom edema/injury; but only fair agreement for diagnosing injury to the anterior inferior tibiofibular ligament and in determining the width of syndesmotom separation. There was a significant correlation between the width of syndesmotom separation and time lost, but no significant correlation between individual syndesmotom ligament injury or proximal extent of syndesmotom edema/injury and time lost.

Conclusion: While ankle MRI can identify syndesmotom disruption with a high degree of interobserver agreement, no association was demonstrated between the extent of injury on MRI and the time to return to play following a high ankle sprain.

Clinical Relevance: In athletes with suspected high ankle sprains, MRI may help confirm diagnosis or suggest alternative diagnoses when the syndesmotom supporting structures are intact. However, the severity of ligamentous and syndesmotom disruption on MRI cannot help predict recovery times.

Keywords: syndesmosis; football; ankle; reliability; magnetic resonance imaging

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The most frequent injuries sustained by athletes occur at the ankle joint, with prior research showing that ankle injuries constitute 30% to 45% of all injuries in some sports.⁴ While the majority of these injuries are lateral (inversion) ankle sprains, studies have shown that syndesmosis (“high”) ankle sprains represent 1% to 20% of ankle sprains in the general population.^{3,6,7,9} However, in contact sports, such as football, hockey, and lacrosse, they tend to represent a larger percentage: between 31% to 74% of all ankle sprains.^{3,7,22} Furthermore, it has been shown that time to return to play is significantly greater following syndesmosis sprains as compared with lateral ankle sprains.^{3,7,8,22} Prior studies have described proposed mechanisms of injury, physical examination findings, and diagnostic methods, but there has not yet been a reliable method proposed to assess the severity of a syndesmosis sprain. Both physical examination and radiographic methods have attempted to distinguish the severity of sprains.^{2,3,9,15,18,19,22} For example, Nussbaum et al¹⁵ correlated the length of interosseous tenderness—measured from the distal tip of the fibula proximally—and a positive squeeze test to the number of days missed from competition.

Magnetic resonance imaging (MRI) has been reported to be an accurate means of visualizing the anatomy of the normal and injured syndesmotom complex. Studies have shown MRI to have relatively high sensitivity, specificity, and accuracy in diagnosing syndesmotom injury, but none have attempted to classify the findings into categorical grades of severity.^{5,11,12,16,17,20,21} However, the previous literature is limited in that most studies do not report the number of observers (ie, MRI readers) included in their data, nor do they report intra- or interobserver reliability of diagnosing syndesmosis injury. Finally, these prior studies do not provide objective measurements of the extent of syndesmotom ligament tears, edema, or syndesmotom widening from the MRI. Only one study, to our knowledge, attempted to compare the findings between 2 readers. These authors reported excellent agreement in diagnosing anterior inferior tibiofibular ligament (AITFL) and posterior inferior tibiofibular ligament (PITFL) injury on MRI; however, their findings were limited to these 2 anatomic structures.¹³

The purpose of this study is twofold: (1) to analyze the interrater reliability of these MRI findings in the evaluation of syndesmosis ankle sprains in American football players and (2) to correlate the MRI findings of these sprains with time lost from play in this athletic cohort. We hypothesize that accepted MRI criteria for syndesmosis ankle sprains—including the degree of injury to the individual structures comprising the syndesmotom ligamentous complex—can be read with a relatively high degree of reliability among radiologists and that these criteria will correlate with the time lost from play, thus acting as an indicator of injury severity.

MATERIALS AND METHODS

This study is a retrospective review of the records and MRI findings of players from a single National Football League (NFL) team who sustained a primary syndesmosis sprain.

Team records over a 10-year period (1998-2008) were reviewed using the league's injury surveillance database and team medical records. Players were included if they had (1) a clinical diagnosis of a syndesmosis sprain by mechanism of injury and clinical examination and (2) a corresponding MRI record that confirmed it, obtained on a 1.5-T scanner at our institution within 7 days of injury. Other inclusion criteria included completion of a conservative treatment regimen and documented return to play at the NFL level. Exclusion criteria included associated fractures (other than small fibular avulsions) to the tibia, fibula, or talus; absence of MRI within 7 days of injury; surgical treatment; prior significant ankle trauma (ie, fractures other than minor avulsions, dislocations, or grade III ankle sprains); and failure to return to play at the NFL level. *Return to play* was defined as participating in football-related activities in team-sanctioned practices or games.

The diagnosis of a syndesmosis sprain was made provisionally by the team's certified athletic trainer with confirmation obtained by the team orthopaedist. These players typically described an injury mechanism involving forced internal rotation of the leg with the foot planted or eversion of the ankle by a direct blow to the lateral aspect of the ankle. Characteristic physical examination findings included pain upon palpation of the anterior and posterior tibiofibular ligaments, pain posterior to the lateral malleolus and distal fibula, and pain with external rotation of the ankle while the leg was stabilized by the examiner. In addition, the “squeeze test”⁹ result was often positive, whereby the pain was elicited at the ankle joint while the examiner compressed the tibia and fibula at the midleg level. Static plain radiographs were obtained on the majority of players to rule out a bony injury or gross widening of the syndesmosis. Dynamic stress radiographs were obtained at the discretion of the team's orthopaedist if plain radiographs yielded negative results and there was significant damage to the syndesmosis and interosseous membrane. No attempt was made to correlate the findings on MRI with those of the plain radiographs because of the limited number of players and lack of standardized stress radiographs.

Data were collected on player age, height, weight, body mass index, position, date of injury, activity at the time of injury (blocking, tackling, etc), nature of competition (ie, practice or game), number of practices missed, number of games missed, and total days lost to injury.

MRI Criteria for Syndesmosis Sprains

Each player underwent MRI of the ankle and distal leg within 7 days of injury on a 1.5-T magnet (Esprey, Siemens Medical Systems, Issaquah, Washington) using a dedicated extremity coil (Siemens or In Vivo, Gainesville, Florida). Players were positioned supine with the ankle in neutral flexion. Transverse fast spin-echo T2-weighted images with fat suppression (TR 2500-4000/TE 54) were performed with a 150-mm field of view, 4-mm-thick slices, and 0.8-mm interslice gap. Other parameters included echo train length, 7; imaging matrix, 256

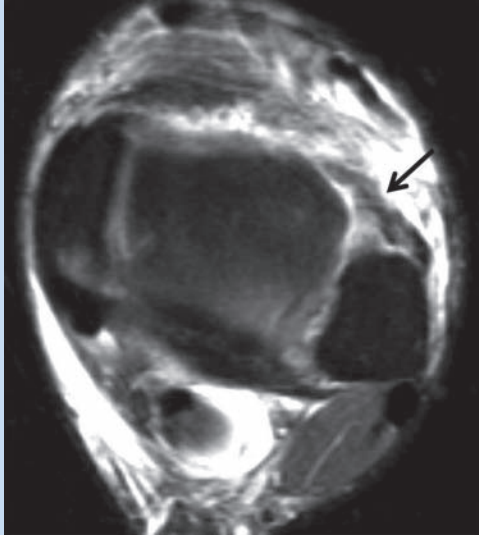


Figure 1. Anterior tibiofibular ligament tear (arrow). The ligament is edematous and avulsed from the tibia.

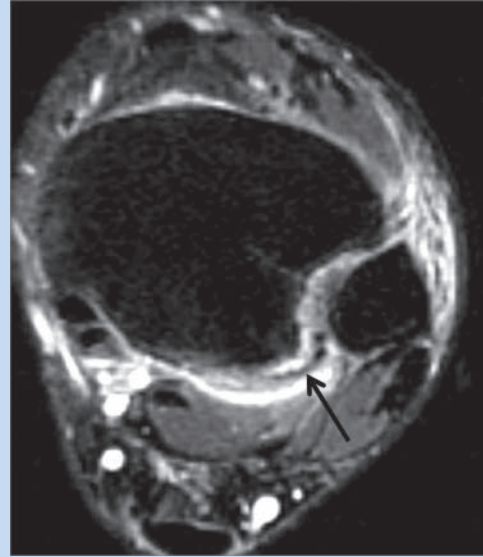


Figure 2. Posterior tibiofibular ligament tear (arrow). The ligament is edematous and avulsed from the fibula. There has also been stripping of the ligament from the posterior tibial periosteum.

× 256; and number of excitations, 2. Additional transverse T1-weighted images, sagittal T1-weighted and STIR (short tau inversion recovery) images, and coronal T1-weighted and T2-weighted images were included as part of the diagnostic imaging protocol, but these sequences were not reviewed for this study. Each study was monitored by a musculoskeletal radiologist, and in cases where an initial review of the images demonstrated that soft tissue injury extended proximal to the imaged volume ($n = 14$), the extremity coil was repositioned to cover the distal one-third of the leg, and the transverse T2-weighted images were repeated. If these additional images still did not include the entire extent of the soft tissue abnormality, no further imaging was done, to keep the examination time reasonable. A larger coil was not used so that high spatial resolution could be maintained.

Three musculoskeletal subspecialty radiologists retrospectively reviewed imaging studies on a PACS workstation: 1 was an attending radiologist with greater than 15 years of experience interpreting musculoskeletal MRI examinations, and 2 were musculoskeletal radiology fellows. All acted independently and were blinded to the identities and clinical data of the players, as well as the results of the other radiologists' MRI interpretations. The observers scored each study for the specific ligaments injured, the proximal extent of syndesmotc edema, the proximal extent of syndesmotc membrane injury (disruption), the width of syndesmotc separation, and any other associated chondral, bone, or soft tissue injuries (fracture, bone bruise, etc). The ligaments assessed for injury included the AITFL and PITFL. The status of the AITFL (Figure 1) and PITFL (Figure 2) were scored as *intact*, *completely torn*, or *abnormal*, where *abnormal* included all other appearances of the ligament (eg, partly torn, scar,

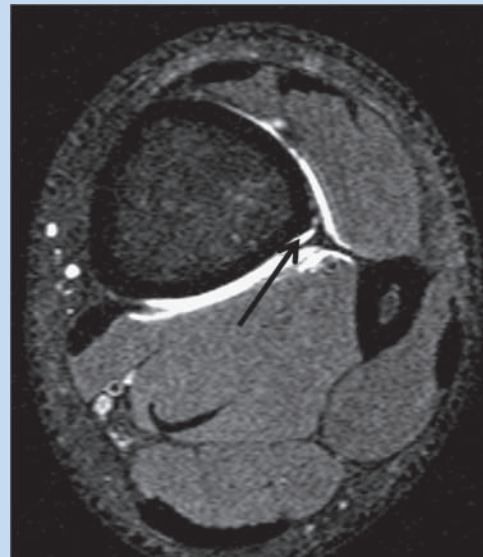


Figure 3. Torn syndesmotc membrane. The membrane is avulsed from the tibia (arrow).

thickened, or absent). The status of the syndesmotc membrane was also assessed for injury and so classified as *intact*, *avulsed from the tibia*, *torn in midsubstance*, or *avulsed from the fibula* (Figures 3 and 4). The proximal extent of syndesmotc membrane injury was determined from identification of the most proximal MRI that demonstrated a disrupted syndesmotc membrane and by cross-referencing this image with the

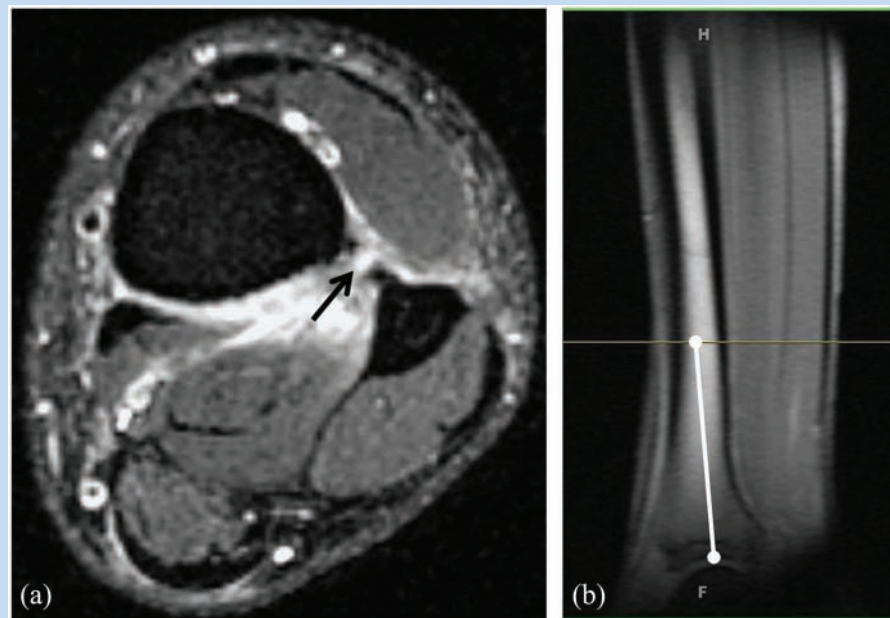


Figure 4. Torn syndesmotom membrane. The axial image (a) shows a tear (arrow) of the midsubstance of the membrane. The sagittal scout image (b) was used to determine the proximal extent of the syndesmotom membrane injury.

long-axis scout images obtained at the beginning of the study to measure (in centimeters) the distance from this image to the proximal extent of the talar dome (Figure 4). If the membrane disruption extended superior to the most proximal transverse image, the location of the most proximal image was used for measurement. The proximal extent of surrounding soft tissue edema was determined from identification of the most proximal MRI that demonstrated edema in the fascia, muscles, and/or periosteum surrounding the syndesmotom membrane and by cross-referencing this image with the long-axis scout images obtained at the beginning of the study to measure (in centimeters) the distance from this image to the proximal extent of the talar dome (Figure 5). The width of syndesmotom separation was determined in the axial plane by first drawing a line between the bisectors of the tibia and fibula and measuring the distance from the lateral tibial cortex to the medial fibular cortex parallel to this axis at 3 slices (13.6 mm) above the talar dome (Figure 6). Each MRI record was read independently by the 3 radiologists according to these criteria and the data recorded.

The 3 observers discussed and agreed on the measurement methods as a group. Before scoring the cases for this study, the observers independently performed the above measurements on 5 MRI examinations of patients with syndesmotom ankle sprains, which were not part of the study data set, to ensure agreement for the measurement technique.

Data Analysis

Statistical analysis was performed using SAS software (SAS Institute, Inc, Cary, North Carolina). Interrater reliability was

calculated using Cohen κ coefficients (with 95% confidence intervals) to express interrater agreement for categorical variables, while intraclass correlation coefficients and 95% confidence intervals were used to express interrater agreement for continuous measurements. Landis and Koch¹⁰ have provided subjective categorical interpretations of the κ values that were used for the calculated values. These interpretations are as follows: < 0, poor agreement; 0.01-0.20, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; 0.81-1.00, almost perfect. Cohen κ coefficient expresses interrater agreement beyond that expected by chance and is calculated as

$$\kappa = (\text{observed} - \text{expected}) / (1 - \text{expected}).$$

Categorical variable data were analyzed on the original scale and then on a collapsed scale (*intact* versus *not intact*, with abnormal ratings being tested in either group to analyze whether they should be treated as *intact* or *not intact* ligaments). Analysis of variance was used to compare time lost from play across groups with the MRI findings of syndesmosis sprains and when significant. Tukey post hoc test was used for pairwise comparisons. $P < 0.05$ was considered statistically significant. Continuous measurement data were analyzed per individual reader as well as collapsed across all readers by the mean and median measurement across all 3 raters. As there was no rationale to establish cut points for the amount of time lost to injury, a median and tertiary split were used to explore the possibility that a cut point does indeed exist (ie, a natural discrimination point where players above and below differ).

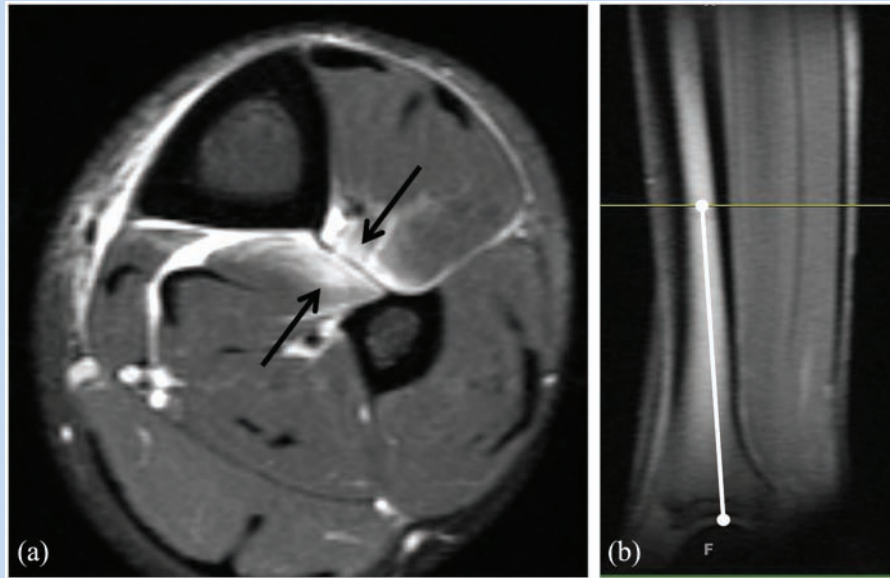


Figure 5. Soft tissue edema. The axial image (a) shows muscle and fascia edema (arrows) around an intact syndesmodic membrane. The sagittal scout image (b) was used to determine the proximal extent of soft tissue edema. The soft tissue edema typically extended superior to the syndesmodic membrane injury.

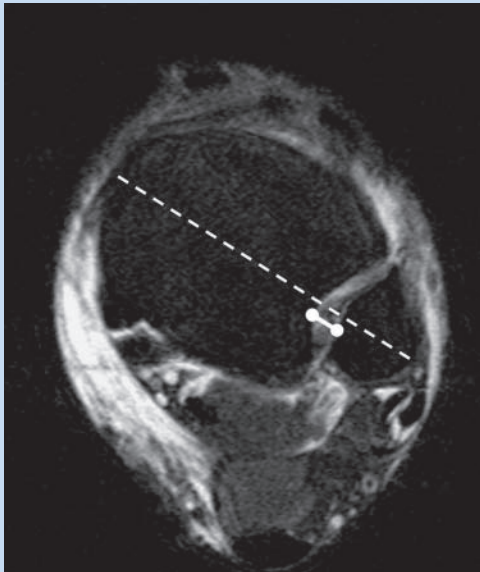


Figure 6. Syndesmodic width. The distance between the tibia and fibula (white line) was measured as the maximum distance parallel to the axis formed between the bisectors of the 2 bones (dashed line) at 3 slices above the talar dome.

RESULTS

Review of team records revealed 17 syndesmodic ankle sprains that met the study's inclusion criteria. These 17 sprains

included 16 players, as 1 player had sustained syndesmodic sprains to both ankles on separate occasions. All players typically had their ankles taped at the time of injury per team rules. The positions of the injured players included 3 defensive backs, 3 defensive linemen, 3 running backs, 2 linebackers, 2 offensive linemen, 2 wide receivers, and 1 fullback. The average age of the players at time of injury was 27.0 ± 2.8 years (range, 22.4-33.1 years). Player height and weight at time of injury averaged 72.2 ± 2.8 in (range, 67-76 in; 183.4 ± 7.1 cm [range, 170-193 cm]) and 236.5 ± 46.9 lb (range, 180-320 lb; 107.3 ± 21.3 kg [range, 81.6-145.2 kg]); average body mass index at time of injury was 31.6 ± 4.7 (range, 26.5-40.4). Sixteen injuries occurred during a game, and 1 injury occurred in practice. Activity at the time of injury included 1 player who was being tackled, 3 players who were tackling another player, 4 players who were blocking, 1 player who was cutting, and 7 players whose activity was unknown. We also did not assess whether the players were able to return to play immediately following the injury. In general, however, the majority of football players who sustain a syndesmodic sprain are unable to continue to compete.

Prior syndesmodic injury was reported in 1 player, on the opposite ankle from the 1 included in this study. The number of days lost to injury averaged 30.1 ± 20 days (range, 8-90 days). We did not specifically calculate practices versus games lost to injury, as game and practice schedules vary throughout the season (preseason, regular season, bye weeks, etc), making total days lost more uniform and accurate. Data were unavailable regarding type of turf (natural grass or artificial), footwear, and weather conditions at the time of injury.

Table 1. Interrater reliability of categorical variables.^a

Structure	Original Scale		Collapsed Scale	
	Cohen κ (95% CI)	Percentage Agreement	Cohen κ (95% CI)	Percentage Agreement
AITFL	0.24 (0.0, 0.48)	75	0.12 (0.0, 0.43)	76
PITFL	0.73 (0.38, 1.0)	96	Same	Same
Syndesmotoc membrane	0.86 (0.74, 0.99)	91	0.73 (0.47, 0.98)	91

^aAITFL, anterior inferior tibiofibular ligament; PITFL, posterior inferior tibiofibular ligament; CI, confidence interval.

Players were treated conservatively with rest, ice, electrical stimulation, ACE wrap or Coban compression (3M Corporation, St Paul, Minnesota), and the use of a walking boot. Weightbearing was increased as tolerated. Rehabilitation was performed with range of motion exercises, with avoidance of external rotation, progressive strengthening of the ankle joint, and proprioceptive training. Running in water was initiated when pain and range of motion allowed, with progression to dryland running, sprinting, and cutting maneuvers permitted as the players tolerated. Players were cleared to return to play when they could perform football-specific activities without pain and showed the ability to recover from their training sessions with little to no pain.

MRI Findings

Interrater reliability was determined for each characteristic anatomic injury to the syndesmosis with further classification given by the Landis and Koch¹⁰ guidelines for Cohen κ . The syndesmotoc membrane was read with almost perfect agreement by the 3 readers, the PITFL with substantial agreement, and the AITFL with fair agreement (Table 1).

There are no published categorical guidelines for intraclass correlation coefficients as there are for Cohen κ , but the Landis and Koch¹⁰ guidelines were applied here because both Cohen κ and intraclass correlation are measurements of interrater reliability. The proximal extent of syndesmotoc injury was read with almost perfect agreement; the proximal extent of syndesmotoc edema was read with substantial agreement; and the width of syndesmotoc separation, fair agreement (Table 2).

Correlation of MRI Findings With Time Lost

Correlation of MRI findings with time lost to injury was analyzed by each reader and then collapsed across all readers. For the individual readings, 2 of the 3 readers (the senior musculoskeletal radiologist and 1 musculoskeletal radiology fellow) found statistically significant correlation between syndesmotoc joint width and time lost to injury ($P = 0.02$ and $P = 0.04$, respectively), with Spearman correlation coefficients of 0.57 and 0.51, respectively. None of the 3 readers individually found statistically significant correlation between the proximal extent of syndesmotoc edema or syndesmotoc injury and time lost to

Table 2. Interrater reliability of continuous measurements.^a

Measurement	ICC (95% CI)
Proximal extent of syndesmotoc edema	0.76 (0.56, 0.90)
Proximal extent of syndesmotoc injury	0.83 (0.67, 0.93)
Width of syndesmotoc separation	0.40 (0.10, 0.69)

^aICC, intraclass correlation coefficient; CI, confidence interval.

injury. When the continuous measurements were collapsed across 3 readers by taking their mean, syndesmotoc joint width was found to be moderately correlated with time lost to injury, with a Spearman correlation of 0.57 ($P = 0.02$), while the proximal extent of syndesmotoc edema and syndesmotoc injury failed to correlate significantly with time lost to play. These same results were achieved when the median measurement was used. With the numbers available, we were unable to find a significant correlation between the intact/torn status of the syndesmotoc ligaments and time lost to play or between the proximal extent of syndesmotoc edema/injury and time lost to play (Table 3) for each reader individually and when the findings were collapsed across the 3 readers. We found that the results from the senior musculoskeletal radiologist were not significantly different from those of the 2 musculoskeletal radiology fellows.

The median split for the data used to explore the possibility that a cut point exists dichotomized the number of days lost and compared the number of players in each tear category with < 22 days lost to injury versus ≥ 22 days. The tertiary split compared the number of players in each tear category with < 20 days lost to injury versus 20 to 30 days versus > 30 days. In both of these splits, no differences were found.

DISCUSSION

American football continues to be one of the most popular sports in the United States, with over 1.1 million participants

Table 3. Days lost to injury by intact/torn ligament status per reader.^a

Ligament	Reader 1		Reader 2		Reader 3	
	n	Days Lost	n	Days Lost	n	Days Lost
AITFL						
Intact	2	21.5 ± 0.7	5	22.8 ± 8.3	2	20.0 ± 0
Torn	15	31.3 ± 21.0	9	24.1 ± 13.3	13	30.8 ± 21.6
Other	0	N/A	3	60.3 ± 25.7	2	36.0 ± 21.2
PITFL						
Intact	16	30.6 ± 20.5	16	30.6 ± 20.5	15	31.1 ± 21.1
Torn	1	22.0	1	22.0	2	22.5 ± 0.7
Other	0	N/A	0	N/A	0	N/A
Syndesmotoc membrane						
Intact	2	36.0 ± 21.2	3	30.7 ± 17.6	5	27.4 ± 16.7
Mids substance tear	5	26.0 ± 12.2	7	25.0 ± 13.1	5	26.0 ± 12.2
Tibial avulsion	8	33.1 ± 25.5	7	35.0 ± 26.9	7	35.0 ± 26.9
Fibular avulsion	0	N/A	0	N/A	0	N/A

^aAITFL, anterior inferior tibiofibular ligament; PITFL, posterior inferior tibiofibular ligament.

at the high school level and over 60 000 participants at the collegiate level.^{14,23} However, the characteristics of football as a collision sport, in which players are cutting, blocking, or tackling on every play, make its participants uniquely susceptible to injury.

Oae et al¹⁶ and Takao et al¹⁷ performed MRI on patients with ankle sprains and reported criteria for the diagnosis of syndesmotoc injury by comparing the MRI results with the findings at ankle arthroscopy. They found sensitivity, specificity, and accuracy for diagnosing AITFL disruption of 100%, 70% to 93%, and 84 to 97%, respectively, and sensitivity, specificity, and accuracy for PITFL disruption of 100%, 94% to 100%, and 95 to 100%, respectively, using 1 or more criteria. Although these results indicate strong diagnostic capability of MRI, neither study evaluated intra- or interrater reliability. There are no data regarding whether any diagnostic criterion for syndesmotoc injury is reliable across multiple observers.

Boytim et al³ and Taylor et al¹⁸ reported on syndesmosis sprains in American football players. They found that time lost to injury for syndesmosis ankle sprains was significantly greater than time missed because of lateral ankle sprains.

The increased time lost to injury in syndesmosis sprains compared with inversion ankle sprains has been reported outside of American football as well. Hopkinson et al⁹ and Gerber et al⁷ reviewed ankle sprains at the United States Military Academy and found significantly longer recovery times for syndesmosis ankle sprains as well as worse outcomes at 6 weeks and 6 months, resulting in longer disability. Similarly, Wright et al²² reviewed syndesmosis sprains in 2 professional ice

hockey teams and found that those with syndesmosis sprains had a significantly longer mean time to return to play (45 days; range, 6-137 days) than those with lateral ankle sprains (1.4 days; range, 0-6 days). These authors also reported that MRI was not helpful in predicting prognosis of syndesmosis sprains in professional ice hockey players. However, this study did not attempt to analyze the reliability of the MRI findings across multiple readers. Therefore, it is impossible to determine whether their findings would have been different if their MRI were read by more than 1 radiologist. Our results are consistent with the time lost to injury in these previous studies, as our players averaged 30.1 ± 20 days (range, 8-90 days) lost to injury.

In an attempt to correlate physical examination findings with time lost to injury, Nussbaum et al¹⁵ evaluated 60 consecutive collegiate athletes with syndesmosis sprains over a 3-year period. They reported a significant correlation in their linear regression model between the length of interosseous tenderness (from the distal tip of the fibula to the most proximal point of tenderness) and the time lost from competition. However, they did not report the Pearson correlation coefficient, nor did they report any interobserver reliability data for their findings.

To our knowledge, this is the first study to compare MRI findings of syndesmosis ankle sprains with time lost to injury while secondarily analyzing interrater reliability among a group of musculoskeletal radiologists. By using relatively strict inclusion and exclusion criteria among a uniform athletic population, we found a variable degree of reliability among different components of the syndesmotoc complex by radiologic

assessment of damage. Injury to the syndesmotom membrane had almost perfect agreement among readers, while the diagnosis of AITFL injury had only fair agreement. This may be due to the nature of the 2 structures. The syndesmotom membrane is a long structure, often visible on MRI, with fibers running in the transverse plane corresponding to the imaging plane. Additionally, the tibial periosteum is often avulsed from the syndesmotom membrane, allowing for easier visualization (Figure 3). Conversely, the AITFL is a smaller structure (seen on only 2 or 3 images based on MRI) with an oblique course relative to the transverse imaging plane. It is frequently distorted by fluid in the joint and syndesmotom recess on MRI even when it is intact, which makes it difficult to distinguish normal from abnormal tissue and may account for the only injury parameter with fair interrater reliability. We do not believe that spatial resolution for the MRI examinations was a major factor limiting AITFL evaluation. The resolution used is comparable to that used in recent MRI studies investigating syndesmotom injuries⁵ and conforms to guidelines established by the American College of Radiology for MRI of the ankle and hindfoot.¹

Our study was a retrospective study looking at MRI obtained at the time for clinical diagnostic purposes only, rather than trying to prognosticate the recuperation times of the athletes. It was therefore necessary to keep examination times reasonable; thus, for some of the most extensive injuries, the extent of soft tissue edema may have been underestimated, although there were only 2 players in the study whose MRI findings were read by more than 1 reader to have syndesmotom membrane injury or edema that extended proximal to the image field. Additionally, the player with the highest recorded syndesmotom injury actually returned to play well below the average time to return to play, which suggests that even extending the MRI more proximally in these patients would have yielded similar results.

For this study, we intentionally employed musculoskeletal radiologists, 1 attending musculoskeletal radiologist and 2 musculoskeletal radiology fellows, so that the MRI would be read with the greatest level of assumed expertise. Although we tried to vary the level of expertise among our radiologists, our findings may not be applicable to general radiologists or even to practicing sports medicine physicians given the technical expertise required to interpret posttraumatic ankle MRI. Even after deciding a priori the criteria to use to grade the degree of injury to the individual syndesmotom ligaments, these radiologists' findings varied somewhat in their interpretations, although they did have predominantly substantial interobserver reliability. Thus far, there is no better diagnostic modality to assess these injuries. Nevertheless, the degree of injury does not appear to reliably correlate with time lost to injury, at least in professional American football players. It may be that the nature of this sport does not allow for such correlations given the differing positional demands and strenuous forces imposed on the ankle.

Given the results of this study, we must question the routine indication for MRI in the setting of a high ankle sprain. Since the diagnosis of a high ankle sprain was made clinically, there was no significant prognostic information from MRI, nor did

it affect treatment decisions. This should not be interpreted as though there is no role for imaging in these patients. We believe that MRI is useful when there is clinical uncertainty regarding whether an athlete sustained a high versus low ankle sprain, since a significant difference in time to return to play has been shown between patients of each case.^{3,7,9,22} Second, we believe that there are cases where MRI is useful when it is not clear whether an injury represents a high ankle sprain or a diagnosis that mimics a high ankle sprain, such as peroneal tendon or retinacular tears, distal fibular occult and stress fractures, talar dome and tibial plafond chondral injury, or calf muscle strain. In terms of the optimal MRI technique, we recommend that the images include the tibiofibular ligaments and distal interosseous membrane to make the diagnosis of a high ankle sprain. However, it is not necessary to continue the examination up to the midcalf, since there is no prognostic benefit regarding the most proximal extent of the injury.

There are several limitations to our study that must be addressed. Despite the fact that we collected data over a 10-year period, we were able to identify only 17 injuries that met our relatively strict inclusion criteria. Although we did not analyze the proportion of total ankle sprains that were syndesmotom sprains during this time, this number seems to be consistent with the number of syndesmotom sprains found in other studies^{3,9,19} of American football players. This small sample size may have affected our ability to calculate accurate κ statistics in measuring interrater agreement. Several syndesmotom ligaments analyzed had skewed distributions of being read as *intact*, *completely torn*, or *abnormal*. For example, even though percentage agreement was high for the AITFL, the κ statistic was poor. Increased sample size and, therefore, more even distributions may have corrected for the "chance" taken into account by the κ statistics that is not reflected in percentage agreement. While we believe that this limitation could not be avoided in our study, as certain ligaments in syndesmotom sprains are more likely to be ruptured, we believe that continued research with data from additional American football players would help overcome this issue and yield more statistically robust results in this patient cohort. Although the observers were blinded to the patient identifiers and their return to play, they were aware that this was a study evaluating high ankle sprains and that the players were all being evaluated for that diagnosis. This knowledge could bias the observers to overdiagnosis of various ligamentous injuries to the syndesmotom structures. Additionally, 1 player in our series lost 90 days to injury, which was 41 days greater than the next-longest time lost to injury. The effect of this number as an outlier was amplified by our small sample size. We were unable to assess time lost per player position because of the small sample size. We believe that this limitation could also be overcome by acquiring additional data to increase sample size. We also did not attempt to correlate our imaging findings with various treatment options (ie, conservative vs surgical repair). This relationship, though interesting, would require many more

patients to formulate any definitive conclusions. Finally, we did not perform stress radiographs to assess the degree of syndesmotic widening. This dynamic technique has been used to detect occult instability of the syndesmosis not detected with static imaging such as plain radiographs or MRI. It could be argued that the stress views would have provided increased sensitivity to the findings of this study. However, our goal was to determine the degree of syndesmotic injury through the use of MRI alone. Furthermore, any stress radiograph would require a standardized degree of force that would be difficult in the setting of our patient population. Further research in this area could incorporate stress radiography as a complement to MRI in the evaluation of these injuries.

This study only evaluated elite athletes (professional) in a single sport (American football). We chose this patient population because the extensive records kept by the team allowed us to identify the exact date of the injury as well as the first day returning to play. Furthermore, the issue of time lost to injury is most critical in elite and professional athletes, where missing a few games can account for a large part of the season. The results may not be applicable to a more general athletic population, nonprofessional athletes, or athletes in other sports. Syndesmosis sprains may be more common in professional athletes playing collision sports and so result in more severe injury than that of other populations because of the size and speed of the players. Additionally, elite/professional athletes may be more motivated than recreational athletes to complete rehabilitation and return to sports quicker for career and economic reasons.

In conclusion, we found almost perfect inter-rater agreement among musculoskeletal radiologists for diagnosing injury to the syndesmotic membrane and in determining the proximal extent of syndesmotic injury; substantial inter-rater agreement for diagnosing injury to the PITFL and in determining the proximal extent of syndesmotic edema, and determining the proximal extent of syndesmotic injury following syndesmosis ankle sprains in professional American football players. However, we found only fair agreement among radiologists for diagnosing injury to the AITFL and in determining the width of syndesmotic separation. With the numbers available in this study, we were unable to demonstrate a significant correlation between individual syndesmotic ligament injury, proximal extent of syndesmotic edema, or proximal extent of syndesmotic injury and time lost to play in these athletes. We did, however, find a significant correlation between the width of syndesmotic separation and time lost to injury, but due to the poor interrater reliability in measuring the width of the syndesmosis, we concluded that syndesmotic width could not be used as a prognostic factor to predict return to play.

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