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Time to Return to Play After High Ankle Sprains in Collegiate Football Players: A Prediction Model

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Background: Determining the severity of high ankle sprains in athletes and predicting the time that an athlete can return to unrestricted sport activities following this injury remain significant challenges.

Purpose: The objectives of this study were (1) to determine if objective measurements of injury severity after high ankle sprains could predict the time to return to play in Division I football players and (2) to determine whether physical examination or diagnostic musculoskeletal ultrasound was more predictive of return to play. The hypothesis was that objective measures of injury severity of a high ankle sprain can be predictive of time to return to athletic participation in collegiate football players.

Study Design: Prospective case series.

Methods: Twenty consecutive Division I collegiate football players with a diagnosis of a grade I high ankle sprain (syndesmosis sprain without diastasis) were studied. Two clinical measurements of injury severity were determined: the height of the zone of injury on physical examination and the height of the zone of injury as defined by diagnostic musculoskeletal ultrasound examination. All athletes followed a standardized treatment program and return-to-play criteria. A regression model and Cox proportional hazards model were developed to determine time to return to unrestricted play as a function of injury severity and player position.

Results: Physical examination but not ultrasound was significantly correlated with time to return to play. Regression and Cox analyses revealed that injury severity on physical examination and player position were significant predictors of time to return to unrestricted play following high ankle sprain.

Conclusions: Injury severity on physical examination and player position are associated with the time to return to unrestricted athletic activity after injury. A model based on the data can be applied to help predict the time to return to unrestricted play in Division I collegiate football players following high ankle sprain.

Keywords: High ankle sprain, syndesmosis, football

High ankle sprains, or injuries to the ankle syndesmosis, are common injuries in athletes. The diagnosis and management of these injuries in the athletic population can be challenging. High ankle sprains in athletes do not resolve as quickly as lateral ankle sprains[4,7,9,15] and can be associated with long-term ankle dysfunction.[6] A survey of physicians and athletic trainers who care for professional sports teams ranked injury to the syndesmosis as the most difficult foot and ankle injury to treat in professional athletes.[11] Determining the extent and severity of the injury and predicting the time until an athlete can return to unrestricted sport activities remain significant challenges in the management of this common injury.[16] Particularly challenging to caregivers and athletes alike is the unpredictable nature of the resolution of these injuries

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and the often-protracted time needed before return to athletic participation.

The objectives of this study were (1) to determine if objective measurements of injury severity after high ankle sprains could predict the time to return to play in Division I football players and (2) if return could be predicted, to determine whether physical examination or diagnostic musculoskeletal ultrasound was more predictive of return to play after this injury. Our hypothesis was that objective measures of injury severity at the time of diagnosis of a high ankle sprain can be predictive of time to return to athletic participation in collegiate football players.

MATERIALS AND METHODS

This study was approved by our institutional review board, and all participants completed informed consent prior to enrollment.

Twenty consecutive Division I collegiate football players with a clinical diagnosis of a grade I high ankle sprain (syndesmosis sprain without diastasis)[5] were enrolled in this study over 3 years. Inclusion criteria included suspected injury to the ankle syndesmosis (anterior and posterior tibiofibular ligaments and interosseous ligament) after acute ankle injury in a game or training session based on physical examination and mechanism of injury. Athletes with prior syndesmosis injuries were excluded from the study. Patients with diastasis of the syndesmosis or associated fractures of the foot or ankle were excluded from the study, as described below.

Diagnosis and Inclusion

Athletes were suspected of having sustained a high ankle sprain if they presented with acute anterolateral ankle pain with weightbearing centered directly over the syndesmosis following a witnessed or reported injury involving external rotation and/or hyperdorsiflexion. Physical examination findings of tenderness over the syndesmosis, a positive "squeeze test,"[9] and a positive external rotation test[1] confirmed the diagnosis. Patients underwent routine ankle radiographs or fluoroscopy to rule out fracture or diastasis of the syndesmosis joint.[8,14] We do not routinely perform stress radiography as part of our standard evaluation of these injuries.

Injury Severity

After enrollment, 2 clinical measurements of injury severity were determined. The first was defined as the height of the zone of injury on physical examination. Specifically, this was defined as the distance in centimeters from the distal tip of the fibula to the highest point of tenderness along the interosseous membrane and anteromedial aspect of the fibula. This method has been described as a measure of injury severity in high ankle sprains.[13] This distance was measured by a single investigator for each of the 2 football teams under study, to minimize variability, and was recorded for subsequent analysis.

The second predictor of clinical severity was the height of the zone of injury, as defined by diagnostic musculoskeletal ultrasound examination. Within 72 hours of injury, both the injured and uninjured extremities were evaluated by musculoskeletal ultrasound examination. Ultrasound images were acquired using high-frequency linear transducers (10-17 MHz; Model iU22, Philips Medical Imaging, Bothell, Washington) by 1 of 2 musculoskeletal ultrasound technologists (9 and 11 years of experience) and were supervised by a single fellowship-trained musculoskeletal radiologist (18 years of experience). The static images and cine clips were then retrospectively reviewed on a digital workstation by the radiologist. The normal interosseous membrane was identified as a thin linear hyperechoic structure extending from the tibia to the fibula. The interosseous membrane was determined to be injured when the membrane was not visualized from abnormal hypoechogenicity. The distance in centimeters from the tibiotalar joint line to the highest point of injury, as visualized on ultrasound, was measured and recorded for subsequent analysis. The anterior tibiofibular ligament was also evaluated and assessed for complete tear. If the anterior tibiofibular ligament and interosseous membrane were not torn on ultrasound, then 0 cm was recorded. If the anterior tibiofibular ligament was completely torn and the interosseous membrane was normal at ultrasound, then 1 cm was recorded as the proximal extent of the injury. A ligament was noted to be normal if it was of uniform thickness and hyperechoic with a compact fibrillarechotexture. A ligament was noted to be completely torn if there was discontinuity and abnormal hypoechogenicity. The calcaneofibular ligament was also assessed by ultrasound, and the uninjured extremity was also scanned in all patients to serve as an internal control.

Participants and investigators were blinded to both injury severity measurements until after the patient had returned to full athletic participation to avoid treatment bias.

Patients underwent a standardized rehabilitation program (Table 1) and were permitted to progress to the next phase after successful completion of the preceding one. Athletes were allowed to return to unrestricted play after meeting standardized return-to-play criteria (Table 2).

Data Analysis

Pearson correlation coefficients with 95% confidence intervals (CIs) were calculated to investigate the direction and magnitude of association between the 2 measures of injury severity and time to return to unrestricted play. A linear regression model (time to return to unrestricted play as a function of injury severity and player position) with 95% CIs was then developed. A Cox proportional hazards model with covariates of injury severity and player position was developed to investigate the effect of player position on return to play. Because of the sample size, player position was categorized either as *lineman* or *other position*.

Data analysis was performed on SAS 9.1.3.

Table 1. Standardized treatment protocol for high ankle sprains.

Phase	Protocol
Immobilization: 1-3 days	Weightbearing as tolerated with walking boot and crutches
	Treatment in the acute phase (0-72 h) includes ice bucket, cold compression boot, ice, pulsed ultrasound, laser, high-frequency electrical stimulation, microcurrent
Range of motion: 3-7 days	Discontinue walking boot, weightbearing as tolerated with crutches
	Continue above treatments, with the addition of the following: contrast whirlpools, ice bucket squats, joint mobilization of foot and talocrural joint, seated pronation/supination, Biomechanical Ankle Platform System, soft tissue work for calf (foam roller/effleurage massage), stretch calf, activate posterior tibialis muscle, modified lifting, stay off of toes/ weight back, aquatic walking, sand walking, gradual increase in weightbearing exercise as tolerated (seated→standing→impact)
Integration: 5-10 days	Discontinue crutches; full weightbearing; restore and maintain normal talocrural and distal tibiofibular joint function
	> 5 days: treat pain symptoms and inflammation as needed, weighted Biomechanical Ankle Platform System, pool running, sand agility, Stairmaster, forward and backward treadmill walking, jogging (grass → turf, tennis shoes → cleats), double-leg plyometric drills on ground to low height
Return to play: 7-14 days	Decreased pain with athletics, return to sport-specific drills/activity
	Dependent on function of ankle: agility drills, straight-line running → cutting, plyometrics (single-leg hopping, bounding, jumping), position drills, modified practice
	Taping—circumferential strap to support anterior inferior tibiofibular ligament in addition to routine ankle taping; arch support to assist control of pronation
	Optional brace for return to practice

RESULTS

Demographics

Twenty consecutive Division I collegiate football players from 2 teams were enrolled in the study between 2007 and 2010. All were men, with a mean age of 19.9 years (range, 19-23 years). The study population included 10 linemen, 3 wide receivers, 3 linebackers, 3 running backs, and 1 defensive back.

Mean time to return to unrestricted play was 15.5 ± 9.5 days (range, 2-30 days). Injury severity measurements included mean height of tenderness of 9.9 ± 4.6 cm (range, 1.8-17.8 cm) and mean height of zone of injury on ultrasound of 3.9 ± 4.9 cm (range, 0-20.3 cm).

Ten of the 20 patients with a clinical diagnosis of high ankle sprain on physical examination had evidence of interosseous membrane tear on ultrasound, with a complete tear of the anterior tibiofibular ligament noted in all 10 (Figure 1). The average superior extent of injury from the anterior tibiotalar joint in these 10 players with both interosseous membrane and anterior tibiofibular ligament tear was 7.4 cm (range, 4-20 cm). There were 6 with complete tears of the anterior tibiofibular ligament and a normal interosseous membrane, where the proximal extent of injury from the joint was recorded as 1 cm. The remaining 4 had normal anterior tibiofibular ligament and interosseous membrane, where the proximal injury extent was therefore recorded as 0 cm. Four had concomitant injury to the calcaneofibular ligament, and 1 had injury to the deltoid ligament. No patients suspected of sustaining a high ankle sprain were excluded from the study with associated fractures or syndesmotic diastasis. No fractures of the fibular head were noted.

Table 2. Return-to-play criteria after high ankle sprain.

Normal gait
Stability in single-leg balance stance
Perform single-leg calf raise
Perform deep "catcher squat"
Tolerate single-leg hop
Jog without limp
Meet position-specific criteria

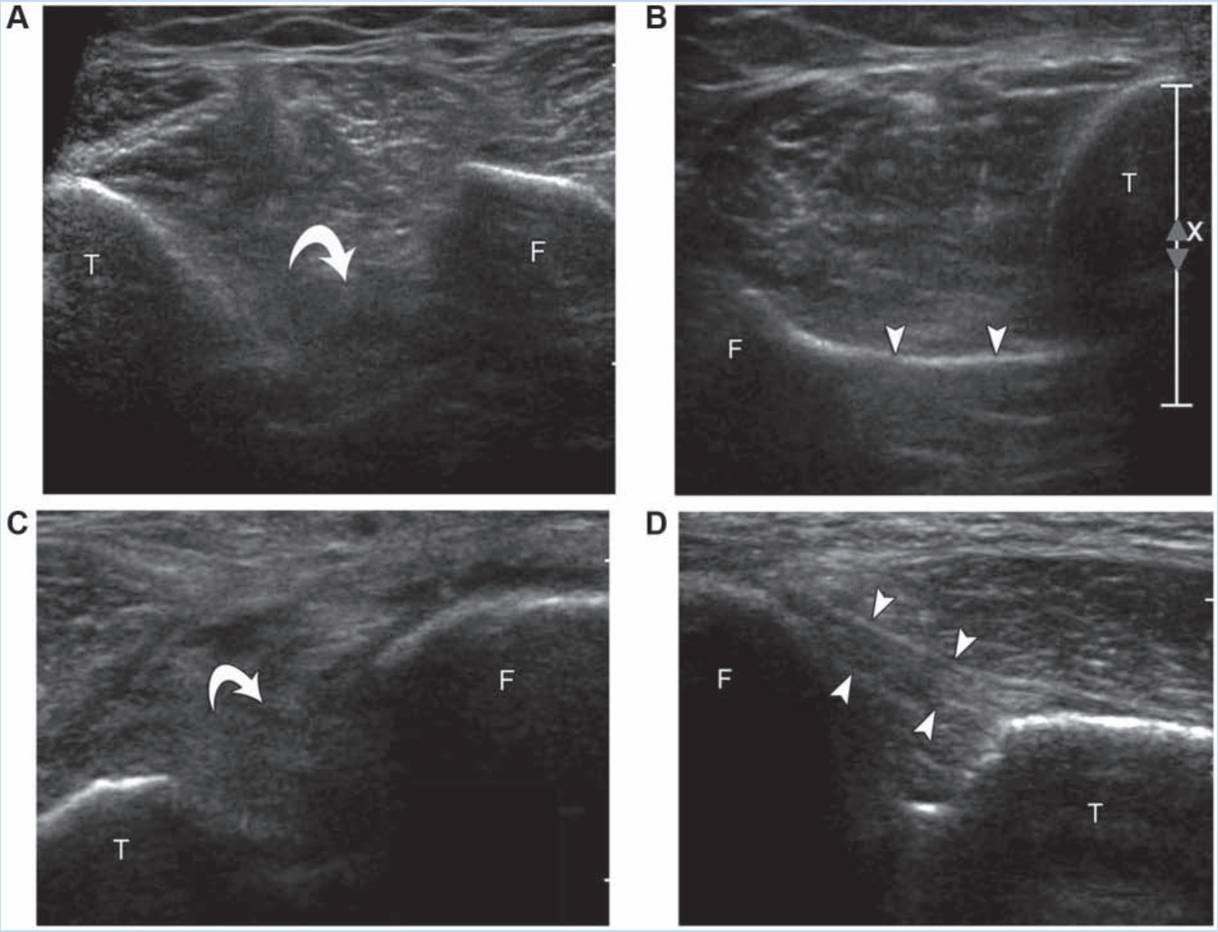

Figure 1. Twenty-two-year-old man with high ankle sprain. (A) Axial ultrasound image over anterior lower leg shows absence of interosseous membrane and abnormal hypoechogenicity (curved arrow). (B) Ultrasound image of contralateral side shows normal interosseous membrane (arrowheads). (C) Oblique ultrasound image long axis to anterior inferior tibiofibular ligament shows absence of normal ligament fibers (curved arrow). (D) Ultrasound image of contralateral side shows normal anterior inferior tibiofibular ligament (arrowheads). T, tibia; F, fibula.

Correlation

There was a statistically significant positive correlation between the height of zone of injury on physical examination (tenderness) and time to return to unrestricted play (r = 0.68; 95% CI, 0.34, 0.86). The correlation between extent of interosseous membrane injury on ultrasound and return to play was weak and without statistical significance (r = .35; 95% CI, −0.11, 0.67). Furthermore, the correlation between injury severity on physical examination versus ultrasound was weak and without statistical significance (r = .31, 95% CI, −0.15, 0.66).

When the ultrasound findings were compared with number of days to return to play, patients with an intact interosseous membrane had an average return to play of 12.6 days (range, 2-26 days), and those with an interosseous membrane tear had an average of 19.6 days (range, 8-30 days), which was not statistically significant (P = 0.19). However, patients with clinically suspected high ankle sprain and a normal anterior tibiofibular ligament on ultrasound had an average return to play of 3.3 days (range, 2-7 days), compared with those with a complete tibiofibular ligament tear, who averaged 19.2 days (range, 8-30 days), which was statistically significant (P < 0.01).

Regression and Cox Proportional Hazards Model

A linear regression analysis revealed that injury severity as measured on physical examination and player position were both significant predictors of time to return to unrestricted play following high ankle sprain. The model suggests that height of tenderness is a significant predictor of time to return to play while controlling for player position (P < 0.01), whereas

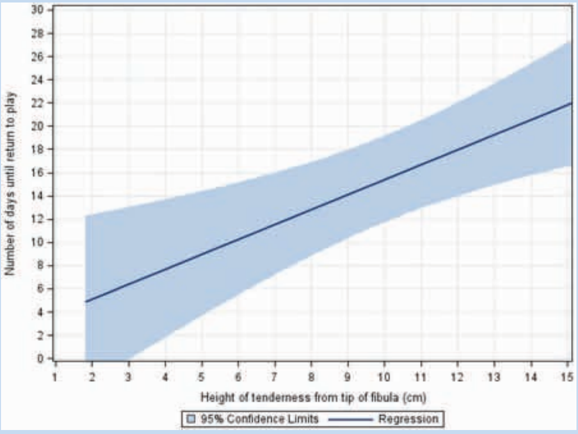

Figure 2. Time to return to play as a function of injury severity.

player position is a significant predictor of time to return to play while controlling for injury severity ($P = 0.04$). A graph of the regression model illustrates that height of tenderness is a predictor of time to return to play (Figure 2). The full regression model, which includes the additional predictor variable of player position, is

number of days to return to unrestricted play = –1.05 + (1.29 × height of zone of injury on physical examination in centimeters) + (6.25 × player position).

For the *player position* variable, lineman = 0 and all other positions = 1.

The Cox proportional hazard model investigating the effects of player position (linemen versus other) and injury severity (height of tenderness) on return to play, while controlling for injury severity on physical examination, suggests that linemen return to play sooner than other positions (hazard ratio = 0.24, $P = 0.01$). In addition, this model confirms that injury severity (height of tenderness) is associated with a delayed return to unrestricted football participation (hazard ratio = 0.87, $P = 0.01$).

DISCUSSION

There is a clear association between injury severity as measured by physical examination and the time to return to unrestricted play following high ankle sprains in Division I collegiate football players.

High ankle sprains remain a challenging injury in football players. Although injuries to the syndesmosis appear to be less common than isolated lateral ankle sprains, their clinical course is more protracted and appears to be more unpredictable. Numerous authors have reported that high ankle sprains in football players result in significantly greater time loss to play than lateral ankle sprains.[4,7,9,15] Professional football players with syndesmosis injuries lost significantly more time (2.5 vs 1.25 weeks), practices (11.7 vs 3.5 practice sessions), and games (1.4 vs 0.3 games) than those with simple lateral ankle sprains.[7] In addition, injuries to the syndesmosis have been associated with chronic symptoms and ankle dysfunction.[6,13,15]

Nussbaum et al reported on collegiate athletes with syndesmotic sprains and also found an association between injury height on physical examination and time lost from athletic participation.[13] Although this study was not restricted to football players, without the effect of sex or sport in their results, a similar mean time lost from athletic participation as the present study was reported (13.4 vs 15.5 days). This study included only football players because different sports place different demands on the ankle. Focusing on a single sport strengthens the external validity of these findings when applied to football players. In addition, player position was included as a covariate in the analysis. Just as there are sport-specific demands on the ankle, position-specific demands exist, and the patients in this study were grouped accordingly. The analysis suggests that football linemen return to play sooner than other positions when controlling for injury severity. Because of the sample size, a further break down analysis by player position was not performed.

Little has been published regarding the rehabilitation of high ankle sprains, and the ideal treatment regimen remains undefined. The few studies that have presented rehabilitation protocols generally follow 3 phases: (1) an early phase of pain and inflammation control; (2) a middle phase focusing on mobility, function, and strengthening; and (3) a final phase of advanced training to prepare the athlete to return to competition.[6,13,16] This treatment protocol also follows the general strategy.

The value in establishing the association between injury severity and time to recovery is the application of these findings toward a prediction model. A mechanism for predicting time to return to play after injury is of value to athletes and caregivers alike. Athletes gain a sense of a reasonable timeline to recovery following high ankle sprain, while caregivers can more clearly define the window for return to play, facilitating communication with players and coaches. These findings allow for a reasonable prediction of such a "window" of return to play following injury. These findings might also be useful to identify injuries for more invasive measures to reduce the risk for further disability from syndesmotic injury.

The sample size of 20 represents a convenience sample that resulted from a planned data collection period over 3 consecutive college football seasons. Despite this relatively small sample size, the results mirror quite closely those reported by Nussbaum et al.[13] A larger sample size might alter the regression model but would certainly allow for a narrower prediction interval.

Historically, the physical examination has been the mainstay of diagnosis for suspected syndesmotic sprains. While there is a role for standard radiographs, the value of stress radiographs is unclear, and they are not part of the standard evaluation for these injuries.[2,3,16] Magnetic resonance imaging can also be used to diagnose injury to the syndesmosis, but its application in this setting has not been clearly defined.[12]

Unique to the present study is the use of diagnostic musculoskeletal ultrasound to generate a prediction model. Dynamic musculoskeletal ultrasound provides accurate diagnosis of anterior inferior tibiofibular ligament ruptures in athletes.[10] For example, 4 athletes suspected of having sustained high ankle sprains in this study had no evidence of syndesmosis injury on ultrasound. These 4 athletes with "false positive" results on physical examination but with normal ligaments on ultrasound had a smaller zone of tenderness (3.8 vs 11.4 cm) and returned to unrestricted sports participation sooner (3.3 vs 19.2 days) than did those with syndesmosis injury on ultrasound. The data suggest that injury severity as measured by physical examination is more closely correlated with time to return to play than diagnostic ultrasound.

In conclusion, (1) injury severity on physical examination as defined by height of tenderness of the interosseous membrane and (2) player position are associated with the time needed to return to unrestricted athletic activity. A linear regression model based on these data may be applied to help predict the time to return to unrestricted play in Division I collegiate football players following high ankle sprain.

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