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# *Rehabilitation after Anterior Talofibular Ligament Injury in Football Players*

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***Abstract.*** Anterior Talofibular Ligament (ATFL) injury is a common ankle sports injury among football players. Traditional rehabilitation methods have gradually shown inadequacies in addressing the recovery of high-level motor functions. Accompanied by the creation of rehabilitation technologies and the further enhancement of the ideas of personalized rehabilitation, numerous new types of rehabilitation strategies have gradually found their way into clinical practice, including the early functional training and weight-bearing, proprioceptive and neuromuscular control training, and ultrasound-guided dynamic monitoring. The approaches have proven desirable effects in facilitating recovery of ankle joint functions and lead to a prolonged rehabilitation period. Nevertheless, the majority of existing research is based on the general population and the research on the specific rehabilitation of the high-intensity, multi-directional sports like football is bound to lack. It is believed that future studies should focus more narrowly on the features of injuries in the context of football, combine the imaging and functional tests, and create more sport-specific and personalized rehabilitation programs to secure the safe and effective re-entry of athletes into sports. The paper is a systematic review of the anatomical pathogenesis and injury nature of ATFL, the usefulness of imaging diagnostics, the essence of key employment in conservative rehabilitation (use of early weight-bearing and proprioceptive training and ultrasound control), and the significance of thorough examination, which is intended to offer both theoretical underpinning and practical guidance.

***Keywords:*** Anterior Talofibular Ligament, rehabilitation, personalized rehabilitation programs

## 1. Introduction

The anterior talofibular ligament (ATFL) is one of the most frequently injured ligaments of the ankle joint, and ATFL injury represents one of the most common injury types in sports activities especially in high-intensity exercise. As a key component of the lateral ankle ligament complex, ATFL injury is commonly encountered in clinical practice [1]. In professional and youth football players, ATFL injury can significantly affect training participation and competition-related decision-making. The imaging studies show that ATFL injury is highly prevalent and often does not occur as an isolated lesion [2]. It has a high incidence of associated injuries. Improper management may substantially impair quality of life and have long-term negative effects on athletic performance and ankle joint

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health. When it comes to rehabilitation management, conventional rehabilitation methods are becoming inadequate to satisfy the existing clinical requirements. As techniques of rehabilitation and the focus on the one-on-one rehabilitation programs have improved, numerous new types of rehabilitation strategies have arisen. Indicatively, certain studies have shown that platelet-rich plasma (PRP) shows a difference in terms of pain and other effects in treatment of the conservative compared to conservative treatment plus platelet-rich plasma, and the difference is evident in the follow-up period [3]. Consequently, guided by the epidemiological feature and available scientific studies, the purpose of the review is to summarize the current development of rehabilitation of ATFL injuries, as well as to comment on their clinical implications in football players. This is aimed at offering a foundation on safer and better return to sport.

## 2. Anatomical features, mechanism of injury and diagnosis of the ATFL

### 2.1. Anatomical mechanism

The ATFL begins at the anteroinferior part of the lateral malleolus and attaches to the anterolateral side of the neck of the talar. It is an ankle structure that is most susceptible to stress during plantarflexion and inversion of the ankle [4]. During plantarflexed action, ATFL is very important in limiting anterior translation and inversion of the talus. It is due to this that it is more vulnerable to injuries due to actions caught at the football field. Jumping, which causes unstable landings can also subject the body to stresses of plantarflexion-inversion, contact with the lateral foot during rapid direction change may significantly increase inversion load, and poor landing control during movement is a further risk factor with respect to ATFL injury. Traditional accounts of the anatomy of the ATFL have long considered it anatomically a single bundle. But through the advancement of anatomical and imaging studies, this essentially single-bundle concept is now questioned. There is some anatomical and radiographic evidence that indicates that structural variability of the ATFL does exist based on showing dissimilar fibular attachment of the two fascicles. Anatomy has also shown that the ATFL attachment is composed of superior band (SB) and inferior band (IB) [5], and these attachment differences can result in differences in gait and functional stability. Therefore, there is a hypothesis that the superior band will be tensioned when the calf is performing a plantarflexion and is more prone to being in the inversion damage when performing sprains. Structural variability can also be used to explain why some patients can still have some ankle stability despite being known to have Image-detected ATFL injury. As such, the training exercises in the rehabilitation course can take various angles of the ankle joint depending on the predominantly used fascicle to give a specific mechanical stimulation and achieve tissue recovery [1]. A gradual adaptation of the ligament-tendon-neuromuscular control system to football-specific loads before moving to running, jumping and directional changes is encouraged in football-specific rehabilitation whereby progressive loading, perturbation of balance and speed tasks are used [6].

### 2.2. Diagnostic worth of ultrasonography and MRI

Imaging assessment of ATFL injury primarily involves ultrasonography and magnetic resonance imaging (MRI), each of which presents distinct advantages in terms of accessibility, dynamic evaluation, and soft tissue visualization.

Systematic reviews and meta-analyses have shown that ultrasonography demonstrates high sensitivity in the diagnosis of ATFL tears and offers the convenience of dynamic stress testing and clinical assessment [7], MRI, on the other hand, provides a more comprehensive evaluation of

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ankle-related structures and can identify cartilage lesions, bone marrow abnormalities, tendon sheath pathology, and injuries to other ligaments, thereby facilitating more comprehensive rehabilitation planning (See Table 1) [7]. Accordingly, imaging modalities should be selected based on clinical judgment following ATFL injury, and in some cases, combined use of both techniques may be warranted to improve diagnostic accuracy and enable more precise rehabilitation planning.

Table 1. Evidence comparison of ultrasonography and MRI in the diagnosis of ATFL injury

| Injury Type | Acute ATFL Injury | Acute ATFL Injury | Chronic ATFL Injury | Chronic ATFL Injury |
|---|---|---|---|---|
| Imaging Modality | MRI | US | MRI | US |
| Pooled Sensitivity (%) | 82.1 | 88.6 | 86.3 | 98.7 |
| Pooled Specificity (%) | 37.8 | 90.3 | 86.8 | 94.0 |

This approach is particularly important for football players, given the high functional demands of the sport. One study reported that ATFL injury rarely occurs in isolation. Among 86 included patients (59 males and 27 females), About 73.3% (63 of 86) of patients had sustained injuries in association with ATFL injury, and 58.1% (50 of 86) of patients suffered an associated injury to the calcaneofibular ligament (CFL). In 29.1% (25 of 86) and 44.2% (38 of 86) of the patients, respectively, there were injuries of the superficial and deep deltoid ligaments. In 17.4% (15 of 86), patients were also injured with the peroneal tendons. Finally, OCDs were also found to be associated in 19.8% (17 of 86) of patients [2]. The results suggest that the rehabilitation plan and the decisions regarding return to sport using only local analgesics or isolated ATFL recovery can be inadequate and even dangerous. Ultrasonography can also be utilized in the early stages of evaluation because it is very sensitive in identifying ATFL injury, and is highly effective in examining the continuity and thickness of the ligaments in clinical practice. Protective strategies and training plans can be modified. In case the patients still have functional limitations during rehabilitation, MRI can be required to obtain a picture of whether or not the adjacent structural involvement or correlated injuries occurs. On the basis of these results, the clinician can make up their mind on whether a change in rehabilitation measures is necessary, or the only way to go is surgery. Consequently, ultrasonography and MRI cannot be considered as substitutes but as complementary methods, the former being more suitable in the early treatment and examination, and the latter advantageous in the overall examination and stratified diagnosis.

## 3. Core strategies of conservative rehabilitation

### 3.1. Early functional training and weight-bearing

Traditional rehabilitation concepts have emphasized immobilization and avoidance of weightbearing during the early stages of recovery, with the assumption that such approaches promote tissue healing. However, with the improvement of rehabilitation science, functional training and controlled loading under pain-limited conditions have been shown to be more effective than traditional approaches. Evidence suggests that early functional training and weightbearing, when pain and swelling are adequately controlled, may facilitate gait recovery and accelerate rehabilitation [6]. One study compared immediate weightbearing with a control protocol in patients who developed chronic lateral ankle instability following arthroscopic lateral ligament repair. A total of 88 participants were included (58 males and 30 females; mean age 30.26 years), and subjects were randomly assigned to two groups by means of a computer-generated method. At all follow-up time points, no significant

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differences were observed between groups in AOFAS scores, Karlsson scores, or ankle range of motion. However, the immediate weightbearing group achieved independent ambulation significantly earlier than the control group ($P < 0.001$). No significant differences were observed in the time required to return to work, jogging, or sports activities [8]. For patients with chronic ankle instability after arthroscopic anterior talofibular ligament repair, immediate weightbearing allowed patients to return to unassisted walking more quickly and had no negative effects on the AOFAS score, Karlsson score, time to return to normal life, jogging, sports exercise, and ankle ROM at 3-, 6-, and 12-month follow-ups compared with cast fixation [8]. These findings suggest that immediate weightbearing does not adversely affect rehabilitation and may promote functional recovery. Another propensity-matched study investigated postoperative rehabilitation strategies following arthroscopic ATFL repair. Using a 1:2 propensity score matching method, patients were assigned to an accelerated postoperative rehabilitation program (APRP group) or a conventional postoperative rehabilitation program (CPRP group). Improvements in Karlsson scores ($31.8 \pm 17.6$ vs. $36.0 \pm 13.4$, $P = 0.267$) and Tegner scores (2 [−1 to 6] vs. 2 [0 to 5], $P = 0.168$) were comparable between groups. Although the APRP group demonstrated greater improvement in VAS pain scores compared with the CPRP group ($3.5 \pm 2.3$ vs. $2.2 \pm 0.7$, $P < 0.001$), the clinical significance of this difference remains uncertain due to the lack of an established minimal clinically important difference for VAS pain scores in surgically treated ankle ligament populations. Overall complication rates did not differ significantly between groups (10/54 vs. 7/28, $P = 0.492$). Ligament quality did not differ between groups as assessed by the MRI-determined ATFL quality scores (ATFLQS). The sensitivity and specificity of an ATFLQS threshold of 2.5 (maximal Youden index), predicted functional outcomes were 82.4 and 83.3% [6], respectively. Such results indicate that rehabilitation interventions focusing on early weightbearing exercises, strength exercises, and balance exercise in the postoperative period are not inferior to traditional interventions in the context of safety and effectiveness.

Even though the evidence provided above is based on postoperative populations, it indicates that early weightbearing, strength training, and balance exercises are effective and safe. Notably, the timing of advancement of loading and functional training should not be determined by the timepoints only, but by tissue inclination and the reaction to symptoms. During conservative rehabilitation the progression of training should be guided by symptom response with particular emphasis placed on recovery of ankle dorsiflexion and normal gait under the conditions of controlled pain and minimum inflammatory process. Rehabilitation and progression in training is naturally more complicated in football players. Return to football is not about a direct movement of walking to the competition, but it is necessary to pass through fast walking, jogging, acceleration, deceleration, changes in direction, jumping and landing, ball handling, passing and shooting, and sport-specific tasks performed under contact conditions. Thus, they must start with joint mobility exercises, which are followed by the use of isometric contractions and light-weight, closed-chain exercises. They must gradually increase their complexity and conduct detailed evaluation at every stage. In the case of football players, the resumption of more intense running and jumping needs to be considered only with the full-scale assessment of sufficient movement stability, joint damage, and neuromuscular responsiveness as a premature rebound can additionally raise the chances of re-injury significantly. A prospective randomized controlled trial revealed both the PRP and conservative treatment arm had significant changes in the preset baseline VAS pain scores, 4, 6, 12, and 24 weeks ($P < 0.0001$). The intergroup comparison indicated that at every point of the follow-up, lower pain scores were observed in the PRP group. Also, the functional outcomes which were measured using Foot and Ankle Disability Index (FADI) were significantly better after some time in both groups (P

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< 0.0001) with a higher FADI score at the PRP group when compared to week 4 and beyond [3]. Currently, PRP as an adjunctive intervention must be regarded as a complementary measure to enhance rehabilitation and reduce the symptoms, instead of substituting weightbearing and neuromuscular control training. PRP could be an additional supplement in patients with intractable symptoms or prolonged recovery and is recommended in case of incorporated image and functional evaluation.

### 3.2. The proprioception and strengthening of the muscles

Proprioception and neuromuscular control impairments are one of the major factors that lead to recurrence of ankle sprains and injury after the initial one. The mechanisms that may be behind it are excessive postural sway during single leg stance and slow control of inversion or eversion during direction change. It can be argued based on the available evidence that combined strength and balance training is more efficient in terms of improving patient-reported outcomes compared with isolated strength training, and that balance and neuromuscular control may be more beneficial in terms of dynamic balance performance restoration [9]. In this way, rehabilitation programs must not focus only on isolated strength exercises like heel raises but instead emphasize the restoration of the proprioception and neuromuscular control. With the progress of rehabilitation, the goals are supposed to go beyond the relief of pain and include functional recovery and rebuilding of ankle stability. The content of the training is usually aimed at restoring of the range of motion of the joint, strengthening, and improvement of the functioning. In football, extreme deceleration, direction changes, movement contact, jumping, landing, playing surface and footwear variability, are all processes that present heavy demands on dynamic ankle stability. Balance and stability training under a functional based rehabilitation model ought to be part of the key elements of rehabilitation. There has been evidence that balance training can enhance activities of daily living, sport functional and dynamic balance with especially marked effect on functional outcome scores [10]. Unilateral loading and balance training can also improve stability of the supporting limb during passing and shooting, cognitive load attentional control, and ankle stability in contact situations. Proprioceptive training and neuromuscular control are therefore to be considered as part of ankle function recovery among football players.

### 3.3. Ultrasound-based monitoring of rehabilitation

As described above ultrasonography can also be applied when carrying out the dynamic assessment as well as when making a diagnosis. The sensitivity and dynamic evaluation benefits of ultrasonography in ATFL have been suggested to be high and require systematic reviews and meta-analyses [11], to understand that it goes beyond initial diagnosis and that ultrasonography could play a different role in follow-ups and in monitoring dynamics. The MRI studies conducted retrospectively have shown that the ATFL injuries are often accompanied with destruction of the nearby structures. Therefore, subjective reduction of pain as the only parameter to determine the process of rehabilitation might not be enough. The addition of ultrasonography to measure the structural and functional changes in the course of rehabilitation could ease the detection of individuals who need to have rehabilitation program changes based on the related injuries and would indirectly hasten the process of recovery. When imaging assessment could be utilized with functional assessment, and patient adherence is sufficient, the two methods could offer a stronger foundation to be used when determining future training or load changes, or even returning to sport.

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ATFL injury diagnosis and treatment cannot solely be dependent on isolated structural findings or subjective judgment; they should be based on an integrated assessment which encompasses anatomy, imaging evidence as well as rehabilitation management. Isolated-structure-based assessment can be inaccurate in assessing injury severity and undermine future ankle stability, especially in highly functioning groups like athletes whose functional demands exceed their current capacity. It has also been shown that imaging evidence shows that ultrasonography is highly sensitive in the diagnosis of tears of ATFL and MRI has some benefits in assessing the morphology of the ligament and any other related injuries. The modalities are to be employed in a complementary form in initial screening and detailed evaluation with a liberal decision-making process according to the clinical presentation particularly in the absence of related injuries in high load athletic groups. Rehabilitation decision-making must focus on the combination of structure and function in the event that there are other prevailing related injuries as opposed to the use of a single dimension of assessment. The outcome of isolated assessment can be unbalanced rehabilitation planning, or imaging improvements may surpass the still-lacking function recovery. Integrated assessment is especially applicable to high-load sport-specific environments and could help optimize individualized rehabilitations approaches. When it comes to the treatment options, comparative PRP and conservative management studies indicate that injection therapy can be an exploratory adjunctive treatment and not the main treatment. The treatment effects should manifest primarily in pain reduction and functional changes. Their role is to be viewed as an alternative to standardized rehabilitation instead of a rehabilitation modality. Contrary to the growing body of research attesting to the diagnosis and rehabilitation on ATFL injury, there are few sport-specific evidences within the high-load and multidirectional activities like football injury. Football demands high rates of dynamic ankle stability and operative rehabilitation and the current research is mainly in population generalities. Future studies are to establish further relationships between imaging, functional recovery, and subsequent return-to-trainings and competitions in football-specific cohorts and the impact of varying injury patterns and related injuries in making rehabilitation decisions and the safety aspect of returns to sport.

## 4. Conclusion

In the rehabilitation management of the Anterior Talofibular Ligament (ATFL) injury among football players, there is a massive advance in several crucial areas in the contemporary research and practice. The anatomical and diagnostic variation in the reason of ATFL being double-bundled and the correlation of an injury mechanism as well as functional stability are clarified at anatomical and diagnostic levels, which has encouraged the focusing of rehabilitation training. Comparatively in imaging assessment, complementary application of MRI and ultrasound has been accentuated achieving the integration of early injury screening to comprehensive assessment of the related injuries and a dependable foundation in coming up with safe return-to-training plans. In the aspect of core rehabilitation strategies, the traditional concept of immobilization has been broken through, and the safety and effectiveness of symptom-guided early weight-bearing and functional training have been established. Training in proprioceptive and neuromuscular control has been placed in the center of interest, and implications of dynamic stability and functional recovery are enhancing to a great extent. Meanwhile, the dynamic surveillance capability of ultrasound has been applied to the rehabilitation process that facilitates to actualize individualized program alteration founded on the two-fold feedback of structural healing and functional adaptation. Looking ahead, it can be stated that technological progress in the given area will be more focused on multi-dimensional integration and smart development. Rehabilitation therapies will also involve real-time biomechanical variables,

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wearable sensor responses and longitudinal style tracking to create an adaptive digital twin rehabilitation course. It is anticipated that the analysis models that are based on artificial intelligence (AI) will result in precise forecasts of the injury recovery curves and the risk of re-injury, thus, the AI-based models will optimize decisions in load progression and the decision on when athletes can resume training. The final direction of development is to transform from a non-uniform sports rehabilitation model into a personalized, end-of-the-cycle health management model that highly incorporates football peculiarities of biomechanics, tactical movement variations and mental load, actually moving to a situation where injury repair is turned into an improvement in standards in sports activity.

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