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Evaluating Sport Related Acute Skeletal Muscle Injuries Using Ultrasonography Assisted with 3-dimensional and Power Doppler Capabilities

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Abstract **Introduction:** In football players' muscle injuries can be either strain injuries or contusions most commonly in the thigh, groin and calf muscles. The diagnosis is based on history, clinical examination, diagnostic soft tissue ultrasonography and Magnetic resonance imaging. **The aim of the work**: The study aimed to assess the value of ultrasonography assisted with 3dimensional (3D) and power Doppler capabilities in evaluating acute muscle injuries among football players. **Materials and Methods:** 40 football players suffered from acute muscle injuries were subjected to 2D , 3D and power Doppler ultrasonography and follow up. **Results**: 16 football players were diagnosed as grade 1 muscle strain, 10cases were diagnosed as a grade 11 muscle strain and 4 cases as grade 111 muscle strain, 6 cases with muscle contusions, 3 cases with muscle lacerations and 1 case with compartmental syndromes. Among them, 12 cases showed intra muscular hematomas of anechoic and mixed echo pattern. All cases were followed up after conservative and surgical management. **Conclusion**: Ultrasonography with its new modalities is highly valuable in evaluating football players with acute muscle injury and making an optimal decision of management.

Keywords: *ultrasonography, 3 dimensional, power doppler, muscle injury*

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1. Introduction

Muscle injuries that occur in football players can be either strain injuries or from trauma by direct external force. Overuse or overstretching of muscle can lead to muscle strain injuries which account for approximately 10-30% of all football injuries most commonly in the thigh (mostly the rectus femoris, hamstring injuries), groin (hip adductors), and calf muscles [1,2,3,4].

Risk factors for muscle strain injuries in football include previous injuries (hamstring and groin), [5] reduced muscle strength [5,6,7] reduced pre-season range of motion (ROM) and reduced core muscle strength [8,9]. Direct external trauma to the muscle can lead to muscle contusion, lacerations or compartmental syndrome.

3 clinical grades of muscle strain are described, grade 1 strain present with soreness and stiffness, but there is rapid recovery and no loss of function, it has a low risk of tear extension and usually heals within 2 weeks of conservative management.

Grade11 strain present with pain and loss of function and there is usually muscle tear and may also partial detachment of muscle from adjacent fascia or aponeurosis as in tennis leg in which the gastrocnemiuos muscle detach from the common aponeurosis with the soleous muscle. It shows a significant risk of tear extension if the player returns early to exercise. Grade111 strain occurs when there is complete myotendinous or tendoosseous avulsion and occur with violent contraction against firm resistance. Grade 111 muscle strain requires early surgical management to avoid muscle shortening, atrophy and complete loss of function. [10] Blunt trauma to the muscle may contribute to muscle contusion and hematoma formation. Diagnosis of a muscle strain injury is based on a detailed history of the mechanism of injury and the presence of symptoms (acute pain, loss of function, swelling). A careful clinical examination to determine the exact anatomical location and grade of the injury is needed. Diagnostic ultrasound and magnetic resonance imaging (MRI) are very valuable imaging modalities that will assist the specialist in confirming the clinical diagnosis of a muscle injury [11,12,13].

Chronic complications of acute muscle injury include muscle hernia, scar formation, muscle atrophy and myositis ossificans [14]. Ultrasonograhy being safe, available and easily performed has significant advantages over the other imaging modalities in evaluating the acute muscle injury. Real time examination offers the ability to perform dynamic scanning of muscles during contraction and relaxation and offers the ability to do guided aspiration and muscle biopsy. 2 dimensional (2D) sonography is usually performed to show muscle hematomas, muscle

tear, abnormal changes in muscle echogenicity and pure muscular fluid collection. Measurement of hematoma or tear length and width can be estimated [15]. The development of 3dimensional (3D) ultrasonography offers the advantages over the 2D ultrasonography as it allows multi planar reformations in axial, coronal and sagittal planes, the coronal scan is considered the blind scan for 2D ultrasonography. It allows volume renderings with surface, minimum, maximum and x ray modes which can give an accurate evaluation of the shape, extension and the boundaries of the lesion and have greater image resolution than 2D ultrasound which helps in detecting the subtle changes in muscle echogenicity. The multiplanar image analysis and Niche mode allow accurate evaluation of the anatomical relationship to the nearby structures and allows more accurate volume estimation [16].

2. Aim of the Work

To assess the value of ultrasonography assisted with 3D and power Doppler capabilities in evaluating acute muscle injuries among football players

3. Materials and Method

Referred 40 football players, their age ranged from18 to 32years and the mean age was 25 years. They were examined in radiology private center between April 2011 and March 2014 .All suffered from acute muscle injury by either overstretching or blunt trauma and complained of painful tender swollen thigh or leg .All were subjected to clinical examination and real time 2D ,3D and power Doppler ultrasound examination on the day or the day after the injury using sonoace x 8(Medison,Korea) ultrasound machine, 5-12Mhz convex linear probe.2D ultrasound exam was done first to the injured muscle at the point of maximum tenderness during rest and during muscle contraction (dynamic scan) and followed by power Doppler and 3D automatic volume scanning with multiplanar reformations in axial ,coronal and sagittal planes with subsequent volume rendering. The report includes the site of injury, the sonographic criteria of the lesion, the length, width and thickness of the tear or hematoma. The estimated volume of the lesion, the ratio between the maximum area of abnormality and the area of healthy muscle at the same level, any pre -muscular fluid collections and the results of the power Doppler assessment [17]. The players were followed up to assess the results of the treatment.

The normal ultrasound pattern of muscle shows the muscle fibers grouped into fascicles separated by fibroadipose septa (the perimysium) and the whole muscle are enclosed in fascial covering (the epimysium) [10]. Grade 1 muscle strain was diagnosed by the presence of focal or diffuse area of increased muscle echogenicity. Grade 11 muscle strain was diagnosed by the presence of focal area of muscle disruption ± intramuscular hematoma. Grade 111 muscle strain was diagnosed by the presence of complete tendoosseous or myotendinous muscle avulsion with large hematoma formation [18,19,20]. Diagnosis of muscle contusion depends on the mechanism of trauma, the presence of muscle enlargement and the abnormal muscle echogenicity. Muscle laceration was diagnosed by the presence of sharp linear muscle fiber disruption. The compartmental syndrome diagnosed by the diffuse muscle group enlargement and the increased muscle echogenicity with impairment of distal leg arterial flow using the color duplex study.

4. Results

16 football players were diagnosed as grade 1 muscle strain with focal or diffuse areas of increased muscle echogenicity (Figure 2). 10 cases were diagnosed as grade 11 muscle strain with intra substance, muscle tear ± hematoma (Figure 3a, b) (Figure 4a, b, c), (Figure 5a, b), 4 cases were diagnosed as grade111 muscle strain (Figure 6a, b) (Table 1).

Table 1. Demonstrate the cases of muscle strain injuries included in our study with their sonographic diagnosis and the way of management

Sonographic diagnosis	Number of cases	%	Management
Grade I muscle strain	16	53.3%	Conservative for 2weeks
Grade II muscle strain	10	33.3%	8Cases conservative for 4weeks.2cases managed surgically
Grade III muscle strain	4	13.4%	Surgical
Total	30 cases	100%	

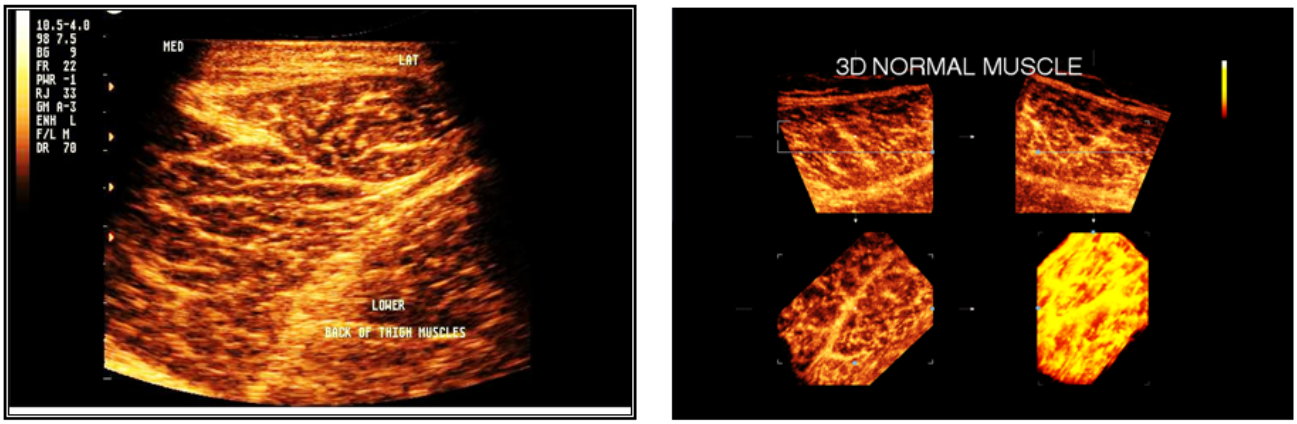

Figure 1. a. Normal 2D sonography of Hamstring muscle complex, **b.** Multiplanar image analysis with 3D reconstruction of normal muscle

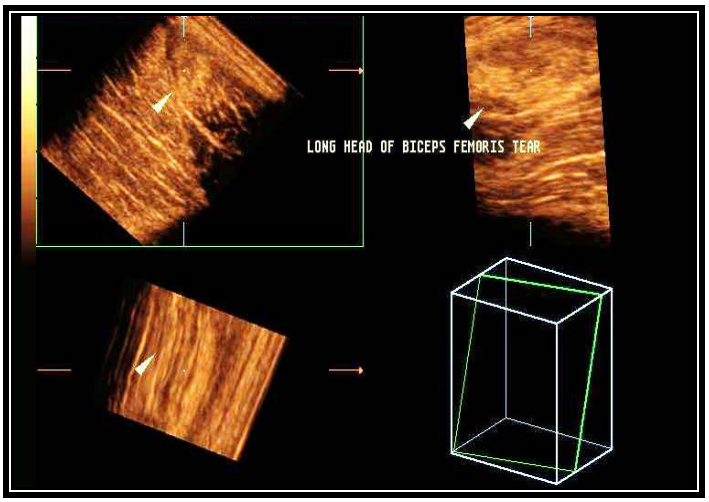

Figure 2. Biceps femoris muscle showing focal area of increased echogenicity (Indicator), clinically grade 1muscle strain

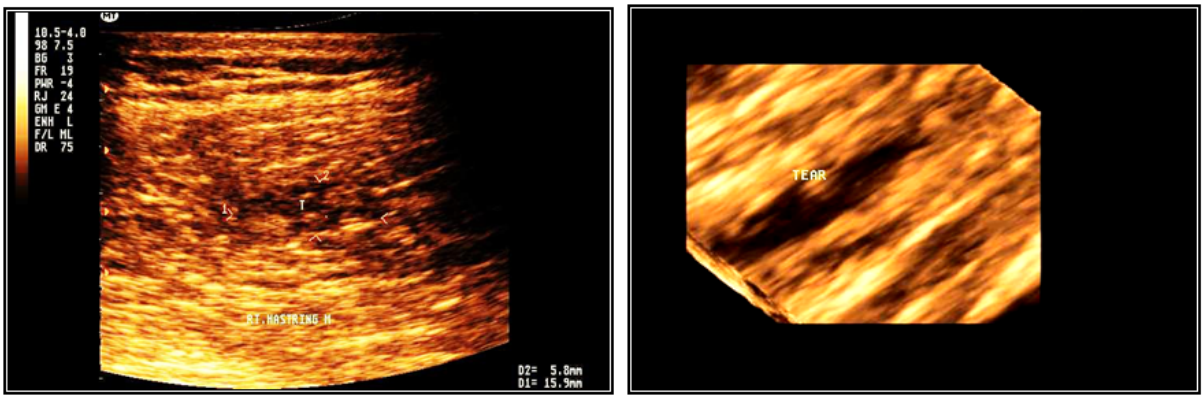

Figure 3. a. 2D sonography showing small hypoechoic muscle tear (arrow), **b.** 3D sonography with surface rendering for the right Hamstring muscle tear(clinically grade 11 muscle strain)

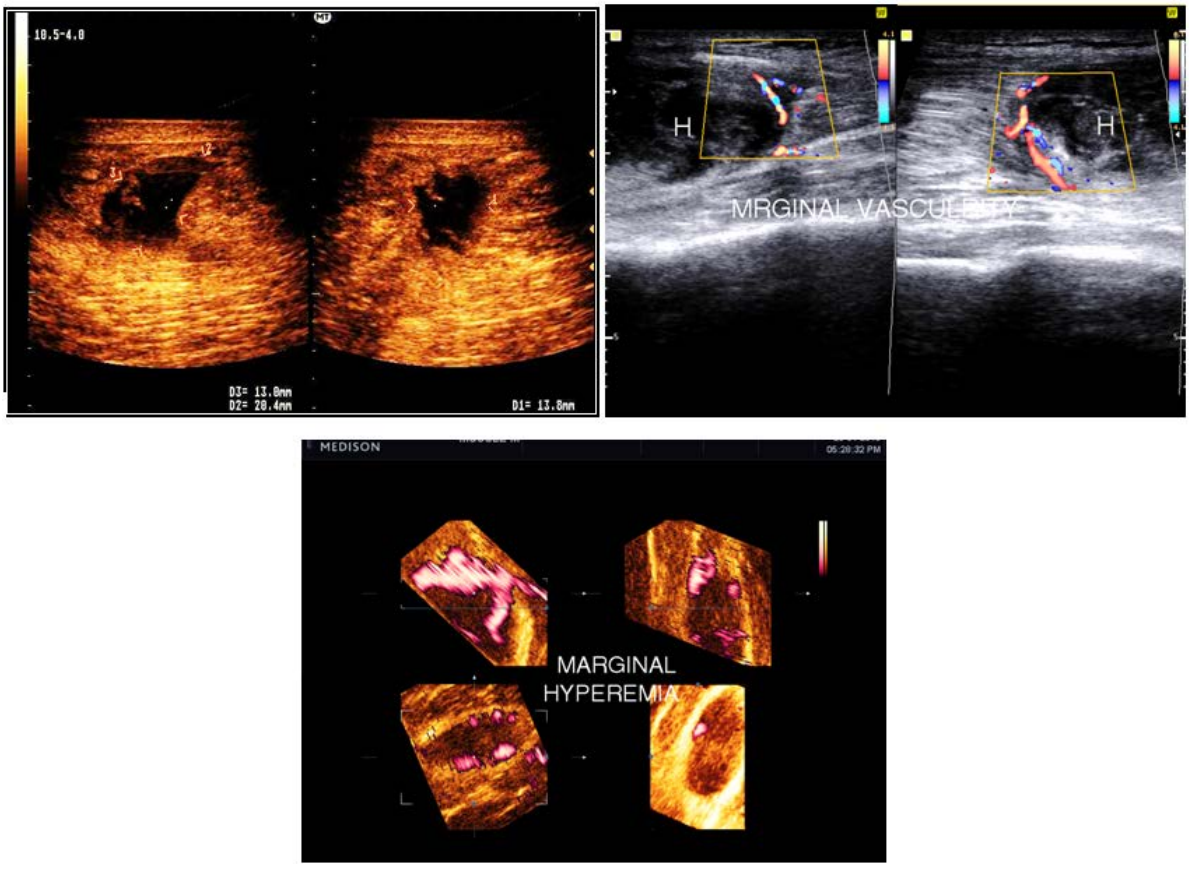

Figure 4. a. 2D sonography of partial muscle tear with hematoma formation, b. Color Doppler study of Partial muscle tear with marginal hypervacularity, c. 3D Power Doppler of partial muscle tear with marginal hyperemia

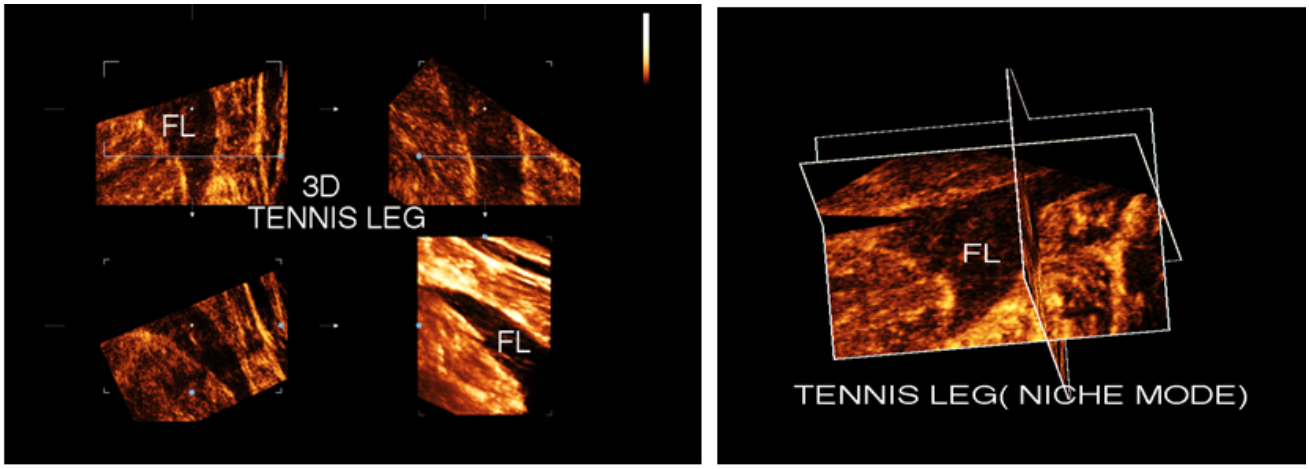

Figure 5a. 3D reconstruction of grade 11 muscle strain (tennis leg), b. 3D sonography reconstruction with niche mode of grade 11 muscle strain (tennis leg)

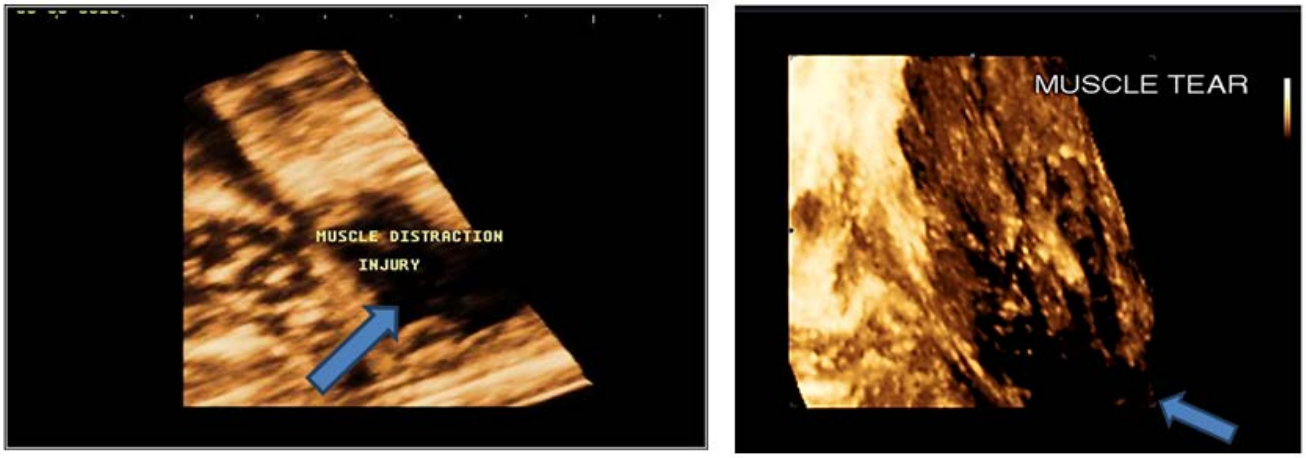

Figure 6a. 3D surface rendering of grade 111 muscle strain with full thickness muscle tear (arrow), b. 3D reconstruction showing complete disruption of muscle fibres (arrow)

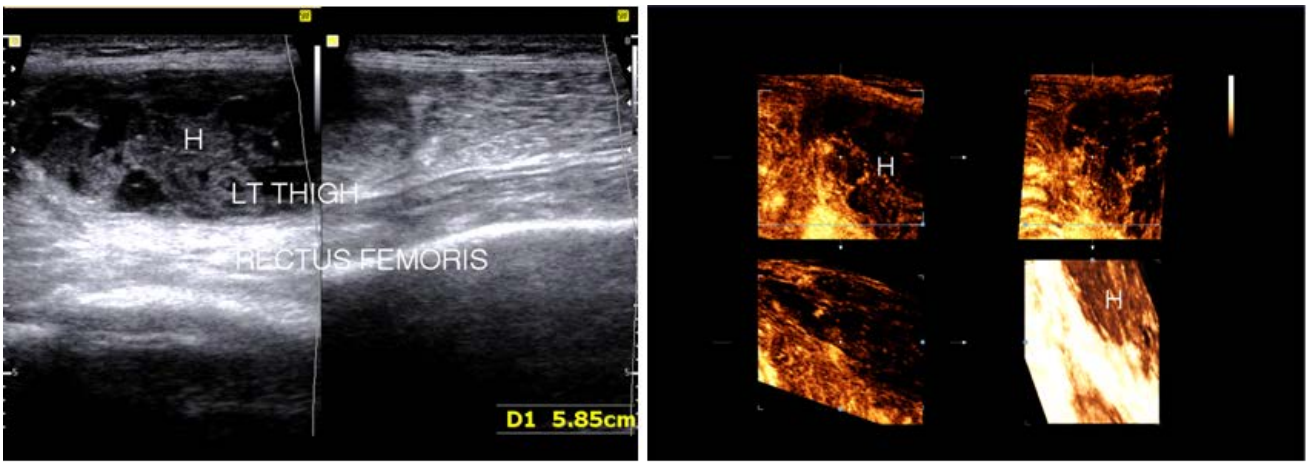

Figure 7a. 2D sonography of intra muscular hematoma with clotted blood (H), b. 3D reconstruction of intramuscular hematoma (H)

6 cases with muscle contusions, 3 cases with muscle lacerations and 1 case with compartmental syndrome. 12 players showed intramuscular hematoma (Table 2) of estimated volume ranged from 5cc to 200cc. The echo features of hematoma is either with anechoic contents of liquefied hematoma or showed mixed internal echo pattern of clotted blood (Figure 7a, b). Patients with a sonographic pattern of grade 1 muscle strain were managed conservatively with an elastic compression bandage and rest for 2 weeks. Patients with a sonographic pattern of grade 11 muscle strain were subjected to conservative management for 4 weeks except for 2 cases with large hematoma and markedly tender swollen muscle which were subjected to surgical management. 4 cases of grade 111 muscle strain underwent surgical management. All football players were followed up after treatment and their response was good to return to exercise and sport competition. 3D sonography was helpful in evaluating the shape of muscle tear and its extensions, the ratio between the injured and healthy muscle areas and in estimating the

volume of the hematomas. It was also helpful in the detection of subtle changes in muscle echogenicity due to high image resolution obtained with surface rendering in comparison with 2D ultrasonography and it helped to discriminate between partial and complete muscle tear.

Table 2. Demonstrate the number of cases with hematomas and the decision of management with regard to their echo features.

Echo features of hematoma	Number of cases	Decision of management
Hematoma with anechoic contents	8 cases	Guided aspiration
Hematoma of mixed echo pattern	4 cases	2 cases with small hematomas managed with conservative follow up.2cases with a large hematoma managed with open drainage
Total	12 cases	

5. Discussion

The clinical assessment of acute muscle injury does not give an accurate idea about the degree or the nature of muscle injury, thus imaging modalities is highly recommended to evaluate the degree and the nature of muscle injury to reach to the optimum way of management. Real time ultrasonography is easily performed, available, safe and non- expensive imaging Technique with various modalities like power Doppler and 3D reconstruction that can be used in evaluating the acute muscle injury.

Previous studies showed that ultrasonography is more accurate than magnetic resonance imaging in differentiating grade 1 from grade 11 muscle strain which is of great importance for the decision of management as regard to the period of conservative management and to the prognosis of muscle injury as grade 1 strain require shorter period of rest and carry better prognosis than grade 11 muscle strain which require longer period of rest and liable to tear extension if the player does not respect the period of conservative therapy. [10] Ultrasonography proved valuable in assessment of grade 111 muscle strain that require surgical intervention and in differentiating liquefied hematoma, which can be managed by guided aspiration from the hematoma containing clotted blood which is better managed by surgical drainage. Dynamic scans augment the ability of ultrasound to detect the edges of muscle defect. Color Doppler enhances the edges of muscle tear by the presence of hyperemia and is valuable for the diagnosis of a compartmental syndrome.

3D ultrasonography adds to the benefits of 2D ultrasonography by accurate evaluation of the shape and extent of muscle tear thus increasing the accuracy of grading the muscle strain by differentiating the grade 11 from grade 111 muscle strain as in grade 111 strain there is full thickness tear whilst grade 11 strain show partial thickness tear which are easily separated by the volume rendering and multiplanar image analysis. Also 3D sonography can detect a small intra substance tear which can escape detection by 2D ultrasonography thus differentiating grade 1 from grade 11 muscle strain. 3D ultrasonography can accurately evaluate the volume of muscle hematoma, which is valuable as large muscle hematomas are better managed by drainage. By 3D ultrasound we can estimate the extent of muscle injury and the ratio between the area of abnormality and the healthy muscle, which is valuable from the prognostic point of view and in evaluating the period needed for rest as larger lesions needs longer periods of absence from competition. Previous Studies showed correlation between the size of muscle tear and the development of muscle fibrosis and correlations between the surface area, the length of muscle tear and the period of rehabilitation. [21] 3D ultrasound can be used for follow up of the lesion to assess the scar formation and to estimate the degree of muscle fibrosis.

6. Conclusion

2D ultrasonography is highly valuable in evaluating football players with acute muscle injury and helps in making the decision of management.3D and power Doppler ultrasonography increase the accuracy of ultrasonography in grading the muscle strain and in estimating the extent of muscle injury.

Conflict of Interest

The author declares that he has no conflict of interest.

Informed Consent

All patients provided written informed consent to enrolment in the study and to the inclusion in this article of information that could potentially lead to their identification.

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