

Ultrasonography of the lateral ligament in ankle sprains

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Background: The acute lateral ankle sprain accounts for 85% of all sprains. The lateral sprain associated with other ligament injuries, such as medial and syndesmosis sprain. In the long-term approximately 20% of the acute lateral sprain develops chronic lateral ankle instability (CLAI). The definition of the chronic ankle instability is persistent pains, repeatedly ankle sprains and episodes of ankle giving away.

Study aim: The aim of this study was by using the ultrasonography to evaluate with the grade of an ankle ligament injury with the purpose to correlate the injury to patient-reported questionnaires outcome.

Methods: A cross-sectional study design performed from 15th of October to 26th of November. 26 subjects (18-40 years) from the emergency department who diagnosed with an ankle sprain (DS934) were invited to a clinical examination and performed a dynamic US examination of ankle ligaments within 15 days after the acute sprain. We evaluated with high frequency (15-6 MHz) ultrasonography the acute lateral ligament injuries (ATFL, CFL), syndesmosis injury (AiTFL) and medial injury (dPT, TCt) only in participants with the positive clinical signs of medial injury. We follow participants up to one year with electronically (PROMQ) per. email sent every 3rd month from the date of the acute primary sprain.

Results: 16 women and 10 men and the mean age was 26.7 years with the mean BMI was 26.6 (17.2-41.3) participated.

Two clinical signs statistically correlated and multiple logistic regression analysis confirmed the results. Positive palpated tenderness AiTFL predicted with partial ruptured ATFL and reported pain during active plantar flexion of ankle predicted with normal CFL confirmed by the US.

Conclusion:

The study predicted patients with partial rupture of ATFL clinical present with tenderness at AiTFL point and patients presented with intact CFL reported pain during active plantar flexion. The overall clinical signs and physical examinations were unreliable factors to predicate lateral (ATFL, CFL), syndesmosis injuries (AiTFL) and medial ligament injuries compared with the US findings.

Ultralydes undersøgelse af de laterale ligamenter ved ankel forstuvninger

Baggrund: Det akutte laterale ankel forstuvning udgør 85% af alle forstuvninger.

Den laterale forstuvning er også set med andre ligament skader, såsom medial og syndesmosis forstuvninger. Omkring 20% af det akutte laterale forstuvning udvikler kronisk lateral ankel ustabilitet. Definitionen på kroniske ankel ustabilitet er vedvarende smerter, gentagne gange ankel forstuvninger og følelsen af fodsvigt.

Formålet med denne studie var, ved at bruge ultralyden til at evaluere og karakteriser en ledbåndsskade i anklen med det henblik på at beskrive og sammenligne den skade som patienten rapporteret spørgeskemaer resultat.

Materialer og metoder: studiet er tværsnitsundersøgelse og startet fra 15. 11.- 26. 11.2015. Det er inkluderet 26 patienter (18-40 år) fra besøgt skadestuen, som er diagnosticeret ankel forstuvning med følgende diagnosekode (DS934). Patienterne blev kontaktede pr. Telefon og hermed blev inviteret til en klinisk og en dynamisk ultralydsundersøgelse af det skadet ledband inden for 15 dage efter den aktuelle forstuvningen. Med en høj frekvens ultralydsscanning den akutte laterale ledbandsskade (ATFL, CFL), syndesmosis (AiTFL) skade) og medial forstuvning (DPT, TCT) kun hos deltagere med den positive kliniske tegn på mediale skade.(dvs. rødme, hævelse, misfarvning og klinisk smerter ved palpation af det medial side af anklen) Derefter fulgtes deltagerne op i et år med (PROMs- patient –rapporteret spørgeskema) pr. mail hver 3. måned fra den dato som de har fået deres primære forstuvning.

Først er der blevet lavet en beskrivelse af hele de opsamlende resultater.

Derefter er der blevet lavt en forhold studie analyse, med to følgende teste:

Spearmans Rank koffient. Hvis de klinisk tegne og ultralydes fund ligament skader

har en p-værdi der er under 0.05 så valgt vi at gå videre og lave en anden statistisk test, som hedder multiple logistisk regression for vores binære værdier. Hvis Multiple logistisk regression har også en P-værdi under 0.05 så kan man statistisk forudsige hvilke kliniske tegn kan være markører for en bestemt ledbåndsskade.

Resultater: 16 kvinder og 10 mænd, og den gennemsnitlige alder var på 26,7 år, og den gennemsnitlige BMI var 26,6 (17,2-41,3) deltog.

Ultralyde af ATFL trukket er 7.7%, halv overrivning af ATFL 27%, og total overrivning var på 62%. Normal ATFL var på 3.85%. AiTFL trukket 15.38%, halv 15.38 helt overrivning 15.38, og normalt AiTFL 54%

CFL trukket 15.38, halv overrivning 23.08 og ingen har total overrivning og normal CFL 62%.

Medial side 35% fik ikke UI af deres ledbånd pga. ingen medial symptomer og undersøgelse var positiv, og mens 54 havde normal ledbånd og 12 vist abnormalitet.

To kliniske tegn statistisk har en sammenhæng og multipel logistisk regressions analyse bekræftede resultaterne. Med UL undersøgelse af en bekræftede halv overrivning af ATFL og normal CFL.

Ømhed ved AiTFL når man klinisk palperer ledbånd, og det viser ved halv overrivning af ATFL. Normal CFL bekræftet af UI undersøgelse forudsiger at patienter med udløst smerter ved aktiv planter fleksion af anklen har en normal bekræftet CFL.

Konklusion:

Resultaterne for ATFL halv skadet forudsiger klinisk ømhed på AiTFL og patienter præsenteret med intakt CFL rapporteret smerter under aktiv planter fleksion.

De overordnede kliniske tegn og objektive undersøgelser var upålidelige faktorer til forudsige lateral (ATFL, CFL), syndesmosis (AiTFL) og medial ledbåndsskader sammenlignet med resultaterne fra UI undersøgelsen..

Introduction:

Ankle injuries are the second common in injury in the sports world after knee injuries.

((1)) In some sports such as basketball; soccer/football, running, hockey, martial arts, ballet/dance and volleyball have a high incidence of the ankle sprain. ((1),(2)).

The lateral ankle sprain is the frequent type and accounted for 20% of all sports injuries ((1)) and estimated 85% of all sprains (3,5). Syndesmosis or high ankle sprain and medial ankle sprain diagnosed between 10- 15% of all ankle sprains. (6)

The severity of the acute lateral sprain ranged from a simple ligament stretch to ligament tears and associated with other ligamentous injuries, syndesmosis sprain (anterior inferior tibiofibular disruption) (7) and medial sprain (8). Up to 26% severe of the sprain seen with avulsion fractures ((1)) and approximately 20% of the acute lateral sprain develop chronic lateral ankle instability (CLAI) ((1)).

Chronic instability symptomatically defined as continually ankle pain, repeatedly ankle sprains and episodes of ankle giving away, ((2)) which causes disability in daily and sports activity life. With CLAI also detected undiagnosed medial and syndesmosis injuries. ((7,9,10)).

Accurate diagnosing of lateral ankle sprain is still challenging because there is a little knowledge of the correlation between the clinical signs of severity with the actual severity of anatomical ligaments injury. ((11)).

To diagnosis ankle, ligamentous complexes injuries different imaging tools are available such as conventional radiology, MRI (Magnetic Resonance Imaging), Arthrography and Ultrasonography (US). (12).

High frequency (up to 14-15 MHz) ((13)) US is useful in the evaluation of ligaments injuries compared to a more limited, expensive use of MRI and invasive arthrography ((11)).

The aim of this study was by using the US to evaluate with the grade of an ankle ligament injury with the purpose to correlate the injury to patient-reported questionnaires outcome.

Method and Materials:

Study design

A cross-sectional study design performed at the Orthopedic Surgery department at Aalborg University Hospital. From 15th of October 2015 and study will continue until the sample size is 100 participants.

Ethics:

The study approved by the local ethics committee (No. 20150037). All subjects received the same treatment as it in Ottawa guidelines for the treatment of ankle distorsion.

Data Source:

A systematically literature research performed in databases of Pubmed and Embase.

Three categories of keywords: Ankle sprains, the name of specific ligaments in lateral, medial and anterior part of ankle and ultrasonography searched.

The keywords extended and searched both as Medical Subject Headings (MeSH) and as text. Articles selected by reading titles, abstracts, and full articles. Further articles derived from the references of the primary articles.

The keywords for sprain extended as "ankle sprain, ankle injuries, eversion sprain, eversion injuries, supinations injuries, supinations trauma, inversion sprain, inversion injuries, sprain classification, sprain location".

The keywords for ligaments at the medial part of ankle expanded to: “Deltoid ligament complex, ankle, deep ligaments, superficial ligaments, medial collateral ligaments of ankle”. The anterior part of ankle ligaments extended to: “Tibiofibular syndesmosis, syndesmotic injuries, Anterior Tibiofibular Ligament, Posterior Tibiofibular Ligament, Anterior Inferior Tibiofibular Ligament, AiTFL, Posterior Inferior Tibiofibular Ligament, PiTFL, Interosseous Tibiofibular Ligament, Distal Tibiofibular Syndesmosis”. The lateral parts of ligaments enlarged to: "Anterior Talofibular Ligament, ATFL, Posterior Talofibular ligament, PTFL, Calcaneofibular Ligament, CFL".

The keywords for ultrasound were: ultrasonography and ultrasound.

Inclusions of Participants:

The database of "Patient Administrative System" the first author searched 3 - 5 times per week for patients with DS934 acute sprain.

From the period of 1st October to 26th November 141 patients diagnosed with DS934. 75 numbers of patients were excluded because 41 of patients were under 18 years and 34 were over 40 years old.

66 numbers of patients looked up in a database of "Clinical Suit" to examine their medical records for exclusions and inclusions criteria.

All subjects had an x-ray of foot/ankle, and none of the patients clinically diagnosed ankle sprain.

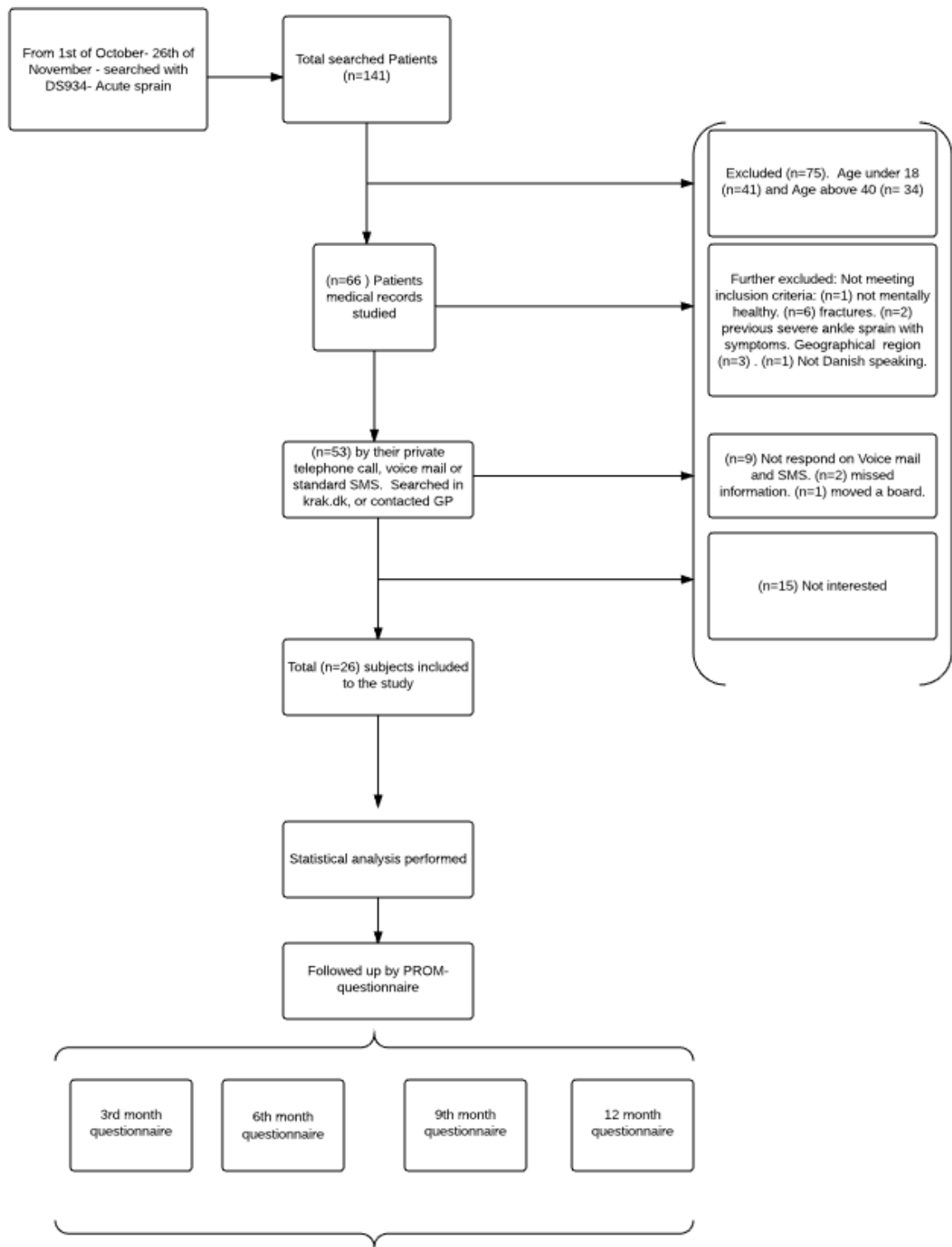


Table 1: The presentation of the study on a flow chart

The Inclusions criteria were age 18 – 40 years sprain within 15 days, mentally healthy, the ability to speak and understand Danish. (14)

. The Exclusions criteria were chronic ankle instability, previous ankle joint surgery or foot dislocation, avulsion or old or new entitled fractures and known with musculoskeletal and neurological disorders.

One patient was mentally unstable. Six numbers of participates excluded because two with previous fracture and four newly entitled fractures and two patients had a previous history of an ankle sprain with ankle symptoms.

Three numbers of participates excluded due to their geographical region (Vejle, Aarhus, Not Danish address). One participate were not able to understand and speak Danish and another one traveled abroad.

53 numbers of subjects contacted either by a call, voicemail, a standard SMS or looked up in a website krak.dk and/or contacted by their general practitioner (GP). 15 Numbers of subjects were not interested in participating, and 9 numbers of subjects did not respond on their voicemail and SMS.

2 of the subjects failed to contact due to there was no updated telephone number in Krak.dk and at GP.

26 numbers of subjects participated in this project.

Data collection:

A Case report format performed to collect demographical data, previous history of ankle/foot injury, mechanism of injury, information about the treatment and treatments choice from Emergency room. Clinical observations and specific tests performed and clinically graded both for AiTFL(Anterior inferior tibiofibular ligament) and the lateral ligaments (Anterior Talofibular ligament, ATFL Calcaneofibular ligament, CFL) noted. The performance of Ultrasound (US) of ligaments and data from the pathological findings recorded.

The demographical data included name, height, body mass index (BMI), information about if subjects have chronic disorders or/and daily use of medication, the standard of activity and smoking status. The previous history of ankle trauma and compare with the actual sprain, location and whether the participate got treatment or not. If they got treatment how and which treatment and in which sector got treatment for ankle trauma.

The demographical data included name, height, body mass index (BMI), information about if subjects have chronic disorders or/and daily use of medication, the category of sport type (Condition, biking, playing with ball and the other type of sport) and hours per week ({0-5}, {5-10} {>10} noted and smoking status.

The category of sport defines as:

“Condition”: running, jogging, orienteering running)

“Biking”: (spinning, mountain bike, bike)

ball sports: handball, basketball, football, tennis, badminton, squash, rugby)

“The Other types”:)(skating, yoga, dance, ski, swimming, yacht)

The previous history of ankle trauma and compare with the actual sprain, location and whether the participate got treatment or not. If they got treatment how and which treatment and in which sector got treatment for ankle trauma.

The mechanism of injury section included the date of injury, the location and how the injury might find.

The treatment paragraph included how and which treatment option which the subjects currently got from Emergency room. The treatment options divided into RICE (Rest, Ice, Compression, and Elevation), Immobilization (crutches) and mobilization (physiotherapy).

The clinical ankle/foot examination paragraph included signs of discoloration, edema, redness, tenderness, joint accumulation, the range of movement of active and passive motion and weight bearing on both and injured ankle tested. ATFL, CFL, AiTFL, lateral and medial malleoli, the 5th basis of metatarsi and hind, mid and forefoot directly palpated and tenderness noted

Instability tests for lateral injury known as the anterior draw test for ATFL, the talar tilt test for CFL performed and compared with uninjured ankle and recorded. If the tests were positive graded in weak, moderate and severe instability. Specific tests for syndesmosis injury external rotation test and squeeze test performed and noted for pain ((5)). The clinical examination performed within 3 to 15 days from the acute sprain. ((11))

The clinical findings outlined in a clinical grading system for AiTFL, ATFL, and CFL. For the lateral ligamentous injuries, the Malliaropoulos classification was used ((3)) without grad of IIIA and grad III B. For AiTFL was graded in The West point ankle grading system used. ((4))

Ultrasound Procedure

US examination performed to evaluate acute lateral sprain (ATFL, CFL) and investigate the prevalence of AiTFL injury (syndesmosis sprain) and deltoid ligamentous injuries (dpT,(deep Posterior tibiotalar, tibiocalcaneal TC) only in participants who presented with one of following medial sided sign in the clinical examination: Discolorations, swelling, medial malleolus sided tenderness.

((12,15)(10).

The US imaging performed in SonoSite FUJIFILM portable US unit using Sonosite HFL50xp linear transducer probe and operating with 15-6 MHz and scanning at a depth of 6 cm. The scanning mode was on MSK and imaging performed within 1.9-2.7 mm window.

AiTFL evaluated both in neutral and slightly in a dorsiflexed foot ((16)). ATFL evaluated in neutral, and slightly a plantarflexed with an oriented medial foot. CFL visualized in neutral and dorsiflexed foot.((13)). The deltoid ligaments evaluated both in neutral and dorsiflexed foot both dPTL and sTCL. ((15).

The lateral part of the ankle examined from bony part of the lateral malleolus. The transducer placed at the longitudinal plan over the distal fibula as the bony landmark. The proximal end of the transducer rotated from the axis of fibula approximately 60 degrees, and a thin fibrillar band is visible – AiTFL.

The transducer moved anteriorly to 120 degrees from the vertical plan, and a straight fibrillar band is visualized - ATFL. Rotated the transducer another 120 degrees in

approximately at 210 degrees from the vertical starting position the CFL is visualized as “hammock” for the overlying peroneal tendon (brevis) and longus.

The medial side or deltoid ligaments performed at dorsiflexed with everted foot and visualized from two bony adjusted marks that were the medial malleolus and the sustentaculum tali bones. Normally the superficial Tibiocalcaneal (TC) ligament and the deep posterior Tibiotalar ligaments (pDT) examined with the US. ((12))

From medial malleolus and sustentaculum tali visualized the Tibiocalcaneal ligament (TC) as a thin hyperechoic band and above overlying posterior tendon. Rotate the distal part of transducer 30 degrees posteriorly a thick striated deep posterior tibiotalar ligament (pdT) visualized. ((12))

According Peetrons et. al(13) the following findings in US examination indicates pathological ligamentous injury for acute sprain cited:

((13)(cited)

- Enlargement of the ligament
- Anechoic zone crossing the ligament or replacing one end of the ligament
- Anechoic band following the superficial border of the ligament, representing edema
- Eventually, avulsion of the bony insertion;
- Eventually, anechoic zone forming a subcutaneous pouch (Figure 20); and
- Edema of the subcutaneous tissue, with lymphatic distension.

Further Peetrons et. all classified(13) US pathological findings in 3 grades. The benign lesion (distension) has intra-articular effusion, but the effusion does not go through the ligament, but the ligament shows hypoechoic and a thin hypoechoic line underscoring it. The middle lesion (partial rupture) has lifted ligament at the insertion and forming a pouch fluid near to bone.

The severe lesion(total rupture) in the US is a complete tear of ligament and effusion that reached the subcutaneous tissue. Tears are often central. ((13)(17))

For CFL following indirectly signs also indicate CFL injured such as fluid in fibular tendons sheath associated with complete and newly CF tear and if tendons move closer to calcaneus bon ((13))

For AiTFL, ATFL, CFL the following pathological findings in the US are noted but for the medial ligaments TC and pdT were only noted normal versus abnormal findings.

Follow up:

A Patient Reported Outcome Measurement Questionnaire (PROMQ) follow subjects up in one year from the acute primary sprain to investigate which grade of injury develops chronic ankle instability. The PROM questionnaire performed electronically in a database of <https://www.smart-trial.dk>. The subjects informed their email address and every 3rd month the PROMQ are sent by email and SMS notification received and a reminder notification received after 7 days from the first mail. The PROM consists of 25 multiple questions with two parts. The first part of questionnaires is about the specific symptoms from the ankle such as tenders, swelling, walking and instability, and the second part is questionnaires EQ-5D-5L.

Statistical analysis:

The CFR data noted in Excl 2013 and analyzed in State view Mach version 14th. CRF was online available on smart-trail.dk and it reduced the typing error. A quantitative descriptive analysis performed over each clinical signs of severity that found for each ligaments injury and compared with US findings. The statistical analysis tests contained a determination of correlation between clinical signs and a binary ligament injury outcome (normal, distension, partial, and total rupture of ligaments) using Spearman's rank correlation coefficient and afterwards performed a multiple logistics regression (statistical cut-off risk= 5%) for p-values less than 0.05 corresponding to Spearman Ranks correlation coefficient.

Results

26 subjects, 16 women and 10 men with different occupations from early retirement pensioner to active worker status include in this study. The mean age was 26.7 years, and the mean BMI was 26.6 (17.2-41.3).

20 subjects (12 females; 8 males) reported weekly workout. The primary category of the sport was "The Other sports" and the next common sport was "Ball Sport" category following "Condition" and "Biking" category. Sports hours per week for {2-5} interval reported by 8 subjects (2 m/6 f), for {5-10} interval hours reported by 7 subjects (3 m/4 f) and over 10 hours weekly workout reported by 5 subjects (3 m/2 f). The level of sport for 14 subjects (5m/9F) was the hobby level. One male played at the local level, and 3 (1m/2 f) played at the regional level. 2 subjects (1 m/1 f) performed at the level of international.

15 right and 11 had left foot injury, and two subjects got injured other part of the body, one Colles fracture, and another one diagnosed a clinical concussion. 13 subjects trauma accident happened in during the workout session. For 11 subjects accident happened in the option of “the other places “(home, town) and for 2 subjects accidents happened at work.

The primary fall mechanism was supination (n=14) and 10 of subjects could not recall the mechanism of injury, and one reported supination with dorsal flexion and only 1 reported dorsiflexion fall. None of the subjects reported pronation and plantar flexion injury.

16 subjects reported past ankle sprain with 4 right, 4 left and 8 with both feet. The level of the previous strain reported following: 13 lower, 1 equal, 2 bigger than the actual sprain injury.

8 subjects of past injuries consulted with professional healthcare and 7 subjects got treated. A professional care did not see the 8 other subjects and only one got RICE treatment by a physiotherapist.

6 subjects with past ankle sprain reported instability, 3 subjects in right, 2 subjects in left foot and 1 in both feet. 4 subjects afterwards reported they have experienced often foot failure during activity 3 in right and 1 subjects in left foot. 2 subjects have experienced seldom foot failure 1 in left and 1 both. Interestingly one subjects with right and left foot with often-experienced foot failure had their actual ankle sprain in this study.

All subjects got X-ray of their foot, treated with ankle support and instructed in RICE-guidelines. Ankle support used between 2- 15 days and some continued after the examination.

12 subjects used crutches privately between 1 to 12 days.

22 subjects got either with or without prescribed painkillers after the injury and 25 followed the RICE guidelines. 16 subjects followed RICE- guidelines from 1-12 days and some subjects planned to continue RICE treatment after participation to this study. 9 used RICE treatment when they had time and/or symptoms.

Clinical presentation at US examinations:

All subjects had ankle swelling, 21 had ankle discoloration and 23 presented with joint accumulation and only one presented with ankle redness. Clinical signs of the foot observed following; one foot redness, 9 subjects with foot swelling, and 5 subjects seen with foot discoloration.

Anterolateral (21), anterior (14), anteromedial (15), posterior (5) tenderness palpated. Tenderness at lateral malleolus (21) and medial malleolus (17) palpated.

Direct ligament tenderness palpation of ATFL (18), AiTFL (15) and CFL (13). A combination of AiTFL and ATFL tenderness palpated in 10 subjects. ATFL and CFL tenderness palpated in 12 subjects and palpated tenderness in AiTFL and CFL were in 8 subjects.

Positive tenderness palpation in foot observed; hind foot(5), midfoot (4), forefoot (2)and 5th metatarsal(2).

Ability to support on both legs observed in 23 (subjects) and ability to support on injured leg observed in 21 subjects.

Active pain observation during active movement of injured ankle reported following plantar flexion (9), inversion (14) and dorsal flexion (9) eversion (11). Passive pain observation during passive movement of injured ankle reported following plantar flexion (15), inversion (19), dorsal flexion (12) and eversion (14).

Under 20 degrees of ankle dorsal flexion compared with another ankle observed for 9 and 17 subjects dorsal flexed above 20 degrees.

Under 50 degrees of plantar flexion seen for 8 subjects and over 50 degrees noted for 18 subjects.

The anterior draw test: 13 subjects tested negative and 2 subjects test grade weak positive compared with another ankle. For 11 subjects a combination of anterior draw and talar tilt test couldn't be performed because of pain and swelling.

The mean day of the test performed, was 8.5 with a range of (3 -15) days. But for those subjects who the test was not possible to perform had a mean day 6.6 and ranged (5-12) days. The mean day for the positive test was 12.5 day with a rang of (10-15) days.

The talar tilt tested negative in 10 and 5 positive, 4 weak and 1 graded moderate instability talar tilt test The mean day for the negative test was 8.5 with a range of (3-13). The mean day of the positive test was 10.2 day with a range of (6 – 15) days. The mean day for not possible test to perform was 6.5 with a rang of (5 -12) days.

For 7 subjects US verified ATFL total ruptured and negative the anterior draw and 6 negative talar tilt test. 8 subjects had a negative anterior draw and presented with total ATFL rupture confirmed by the US. The positive anterior draw test with total rupture of ATFL shown in one subjects (n=1).

Partial rupture of CFL and negative talar test was in (n= 2) subjects.

Positive talar tilt test performed on one subjects (n=1) with partial ruptured CFL. For 3 subjects with partial ruptured CFL the talar tilt test not possible to complete.

The positive external rotation test observed for 8 subjects and the positive squeeze test found for 6 subjects. The mean day of positive squeeze test performed at 7.3 days with a rang of (3 – 10) days of injury. The mean day of positive external rotations test was 6.8 days with a range of (3- 13) days. There were no wide variations between the average of performances of the tests.

Syndesmosis test AiTFL total rupture and positive external rotations test = 2 and squeeze test n=3. The intact AiTFL confirmed by the US but positive squeeze test n= 3 and external rotation test n=2 positive.

At the partial and distension AiTFL there was not positive of squeeze test.

And AiTFL distension, partial and normal ligament 2in each of external rotations test.

No one clinically grades level II, III for syndesmosis sprain classifications. No one classified III for lateral ankle sprain clinical

Ultrasound of examination:
Table 2 shows the percentage of lesion by US for ATFL, CFL, AiTFL and Medial ligaments(table 2)

% ligaments injuries	Distension (Benign)	Partial tear (Middle)	Total rupture (Severe)	Normal
AiTFL	15.38	15.38	15.38	53.85
ATFL	7.69	26.92	61.64	3.85
CFL	15.38	23.08	0	61.54
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% of Medial ligaments	Normal TC and dPT	Abnormal TC and dPT	Not performed US-examination	
	53.85	11.54	34.62	

Ultrasonography of AiTFL and combination with other ligaments lesion
(Table 3)

ATFL-CFL-Medial	AiTFL Benign lesion/distension (total4)	AiTFL Middle lesion/partial (total 4)	AiTFL Severe lesion/complete (total 4)	AiTFL Normal/uninjured (total 14)	Total number of out come
ATFL Benign lesion/distension	1	0	0	1	2
ATFL Middle lesion/partial	2	0	1	4	7
ATFL Severe lesion/complete	1	<u>4</u>	<u>3</u>	<u>8</u>	16
ATFL Normal/uninjured	0	0	0	1	1
CFL Benign lesion/distension	1	1	0	2	4
CFL Middle lesion/partial	1	1	2	2	6
CFL Severe lesion/complete	0	0	0	0	0
CFL Normal/uninjured	2	2	<u>2</u>	<u>10</u>	16
Medial sided Normal TC and dPT	3	3	2	6	14
Medial sided Abnormal TC and dPT	0	1	<u>0</u>	<u>2</u>	3
Not Medial side Ul performed	1	0	2	6	9

Table 4: An overview of the number of the ligament injuries and the combination of it

CFL-Medial - ATFL injuries	ATFL Benign lesion/distension (total 2)	ATFL Middle lesion/partial (total 7)	ATFL Severe lesion/complete (total 16)	ATFL Normal/uninjured (total 1)	
CFL Benign lesion/distension	1	1	2	0	4
CFL Middle lesion/partial	0	1	5	0	6
CFL Severe lesion/complete	0	0	0	0	0
CFL Normal/uninjured	1	5	9	1	16
~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~
<b>Medial sided</b> Normal TC and dPT	0	3	<b>11</b>	0	14
Medial sided Abnormal TC and dPT	0	1	2	0	3
Not Medial side UI performed	2	3	3	1	9
~~~~~	~~~~~	~~~~~	~~~~~	~~~~~	~~~~~
Medial -CFL injuries	CFL Benign lesion/distension (total 4)	CFL Middle lesion/partial (total 6)	CFL Severe lesion/complete (total 0)	CFL Normal/uninjured (total 16)	
Medial sided Normal TC and dPT	2	3	0	9	14
Medial sided Abnormal TC and dPT	0	2	0	1	3
Not Medial side UI performed	2	1	0	6	9

US examination verified total ATFL rupture n= 16 (61.5%), partial rupture n= 7 (26.9%) and distention ATFL n=2 (7.7%) and only one with ATFL normal (3.85%) Total rupture of ATFL (16) and AiTFL (4) (n=20) 76,92 ≈ 77%. Total rupture of

ATFL and partial AiTFL rupture was n=4 (15.4%). Total rupture of ATFL with normal AiTFL n=8. (30,8%)

The combination of total ATFL rupture and partial rupture CFL was 19,23% (n=5).

Total rupture of ATFL with normal CFL n=9 (34.6%)

None of the subjects described with complete rupture of CFL. Only (2) subjects presented with a total rupture of ATFL, AiTFL and partial rupture of CFL 7,7 %.

Complete rupture of ATFL with partial CFL and normal AiTFL presented n=2.

17 subjects got US examination of their medial side of ankle, because at least they presented with one positive clinical signs of medial side (medial swelling, medial

discoloration, medial tenderness or/and medial malleolus tenderness at clinical

examination. Abnormal presentation for medial ligaments (TC and dPT) total= 3. All

Of them seen with a total rupture of ATFL, and (n=2) with complete rupture of

AiTFL and 1 with AiTFL partial rupture, two (n=2)with partial rupture of CFL and

one with normal CFL.

Clinical combination with the US confirmed outcomes (table 5)

Combination of clinical observation with partial and complete rupture of ligaments with the US:

Appendix- table 9 shows the pathological description of the different level of US grads for AiTFL, ATFL and CFL

Tab 5: The US findings of ATFL and AiTFL compared with clinical presentation

	AiTFL distension	AiTFL middle	AiTFL severe	AiTFL normal		ATFL distension	ATFL Middle	ATFL severe	ATFL normal
Clinical observation									
Ankle redness	1	0	0	0		0	1	0	0
Ankle swelling	4	4	4	14		2	7	16	1
Ankle discoloration	4	4	2	11		1	7	13	0
Joint accumulation	4	4	4	11		1	7	15	0
Foot redness	1	0	0	0		0	1	0	0
Foot swelling	1	1	0	7		0	1	8	0
Foot ecchymosis	1	0	0	4		0	2	3	0

Clinical palpation								
Tenderness anterolateral	4	3	3	11	1	5	14	1
Tenderness anterior	2	3	2	7	1	3	10	0
Tenderness anteromedially	2	4	2	7	0	3	12	0
Tenderness posterior	2	0	0	3	0	2	3	0
Tenderness left malloli	3	4	3	11	1	4	15	1
Tenderness right malloli	3	3	3	8	0	4	13	0
Tenderness ATFL	4	3	2	9	1	4	12	1
Tenderness AiTFL	2	4	2	7	1	1	12	1
Tenderness CFL	3	2	1	7	1	3	9	0
Ability to support in both legs	3	3	3	14	2	5	15	1
Ability to support with injured ankle	2	2	3	14	1	5	14	1
Active tenderness e of movement with pain								
Plantar flexion inversion	1	2	1	5	0	1	7	1
Dorsal flexion eversion	3	1	1	4	1	2	6	1
	2	2	1	6	0	4	6	1
Passive movement of ankle cause pain								
Plantar flexion inversion	2	3	3	7	1	3	10	1
Dorsal flexion eversion	3	3	2	11	1	5	12	1
	2	3	1	6	1	4	6	1
	2	2	4	6	1	6	8	0
Range of degree								
Dorsal flexion								
Limited >20 C	3	1	1	4	0	3	5	0
Over 20 C	1	3	3	10	1	4	11	1
Plantar flexion								
Limited > 50 C	3	1	1	3	1	3	4	0
Over 50 C	1	3	3	11	1	4	12	1
Anterior draw test								
Negative	2	2	2	7	2	2	8	1
Positive	0	0	1	1	0	1	1	0
Not possible to perform	2	1	1	6	0	4	7	0
Talar tilt test								
Negative	2	1	3	4	0	1	6	1
Positive	0	1	0	4	0	2	3	0
Not possible to perform	2	2	1	6		4	7	0
External rotations test	2	2	2	2	1	2	5	0
Squeeze test	0	0	3	3	0	2	4	0

Table 6: The Us finding of CFL and the clinical presentation

	CFL distension	CTFL middle	CFL normal
Clinical observation			
ankleredness	0	1	0
Ankle swelling	4	6	16
Ankle ecchymosis	4	4	13
Join accommodation	4	6	13
Foot redness	0	1	0
Foot swelling	1	4	4
Foot ecchymosis	0	3	2
Clinical palpation			
Tenderness anterolateral	3	6	12
Tenderness anterior	3	2	9
Tenderness anteromedially	2	4	9
Tenderness posterior	1	2	2
Tenderness left malloli	3	5	13
Tenderness right malloli	1	6	10
Tenderness ATFL	3	3	12
Tenderness AiTFL	3	4	8
Tenderness CFL	2	4	7
Ability to support in both legs	4	5	14
Ability to support with injured ankle	3	5	13
Active tenderness e of movement with pain			
Plantar flexion	2	4	3
inversion	2	2	10
Dorsal flexion	3	2	4
eversion	2	0	9
Passive movement of ankle cause pain			
Plantar flexion	3	4	8
inversion	3	4	12
Dorsal flexion	2	2	8
eversion	1	4	9
Range of degree			
Dorsal flexion			
Limited >20 C	1	3	9
Over 20 C	3	3	11
Plantar flexion			
Limited > 50 C	1	3	4
Over 50 C		3	12
	3		
Anterior draw test			
Negative	3	2	1
Positive	0	1	1
Not possible to perform	1	3	7

Talar tilt test			
Negative	1	2	7
Positive	2	1	2
Not possible to perform	1	3	7
External rotations test	1	1	6
Squeeze test	1	6	4

Correlation study:

Two clinical signs statistically correlated and multiple logistic regression analysis confirmed the results. The US confirmed ATFL partial rupture and normal CFL.

Positive palpated tenderness AiTFL predicted with partial ruptured ATFL and secondly reported pain during active plantar flexion of ankle predicted with normal confirmed US CFL.

Here are the table from multiple logistics regression:

Normal CFL

Table 7: Normal CFL

US CFL Normal	Coef.	Std. Err.	Z	P> z	[95% Conf. Interval]
Pain during active plantar flexion	-1.87	0.909	-2.06	0.040	-3.65 - -0.089
Cons	1.18	0.57	2.06	0.039	0.058 - 2.29

Table 8: Partial ATFL rupture:

US ATFL partial rupture	Coef.	Std. Err.	Z	P> z	[95% Conf. Interval]
Tendernes at AiTFL	-2.94	1.29	-2.26	0.024	-5.48 - 0.394
Pain	2.26	1.34	1.69	0.090	-0.357 - 4.883
Cons	-1.26	1.13	-1.12	0.264	-3.479 - 0.954

Discussion:

According to our knowledge, it is the first study that uses the US to detect the acute lateral, syndesmosis and medial sprains and follow patients in one year with (PROMQ) for the purpose of comparing the reported outcomes with US findings and define patients who symptomatically develop chronic ankle instability.

The US correctly diagnosed of anterior talofibular ligament (ATFL) sensitivity from 93-100% and specificity of 92-100% and calcaneofibular (CFL) sensitivity from 85-97% and specificity of 92-100% ((11)). The US correctly detected of the anterior inferior tibiofibular ligament (AiTFL) tears 66% sensitivity and specificity with 91%. ((18))

The medial ligamentous complexes are more challenging to visualize in the US than lateral complex because of their complex structure ((12)). But US is an alternative to MRI to visualizing medial ligament injuries.((10)). None of the early studies used the US tool to confirmed medial sprain . In a study, the US used for medial ligamentous complexes injuries in supinations external rotation fractures of the ankle ((10),(1)), and the study had 100% accuracy and 100% sensitive in visualizing supinations external rotation injuries with an intact medial ligament and supination external rotation injury with medial ligament injury ((10)(1,7)

The US result confirmed the frequent ATFL injured and it approved by other studies as well. ((; Nazarenko et al., 2013)Nicola maffulli lateral ankle instability). ATFL is the weakest and most injured (83%) ligaments of these lateral ligaments. ((1,19,20). The US finding confirmed combination of ATFL and CFL injured in 19.23% and the study confirmed no isolated CFL injury that is normally very rare. ((21))

In this study US examination confirmed 12 AITFL (distension, partial, total rupture) and 3 medial injured ligaments (TC, pDT). From emergency room all these patients diagnosed as supination sprain, but with US examination other ligament injuries than only lateral ligament injuries detected.

The reason of the undiagnosed medial and syndesmosis injury might be hard to diagnose compared to lateral sprain. Some studies had shown that patients with CLIA had other ligament injuries. According to a survey deltoid (36%) and syndesmosis injuries(42%) and 90% of syndesmosis injuries were AiTFL lesion detected by 3T MRI were common in patients with CLIA, who were undergoing surgery for lateral ligaments injury. Furthermore, the study did not find a correlation between lateral ligaments injury and prevalence of deltoid or syndesmosis injuries ((22)).

In this study, the 3 abnormal medial ligaments injuries confirmed with the US and all seen with total ruptured ATFL and 2 subjects presented with complete AITFL rupture and one subjects seen with partial AiTFL rupture and 2 subjects presented with partial CFL rupture and only one with normal CFL ligament. The incidence of medial injuries often seen with other severe ligament injuries and the study finding identified in background literature that medial ankle sprain rarely seen isolated and often associated with lateral ligament injuries, syndesmotoc injuries, lateral malleolar and fibular fractures. ((8))

The US ligaments injuries results compared with reported accident mechanism and the primarily reported accident mechanism was supination trauma. It seemed that even though patient remembered the fall accident, they were likely to forget the combination fall. According to literature AiTFL and medial ligament injuries were not only seen in supinations trauma. Other fall directions might have existed.((7)

The correlation study:

Patients with an acute sprain presented intact CFL confirmed by the US predicted to have reported pain during active plantar flexion. The reason for this prediction could be swollen ankle or injured ATFL. Normally during plantar flexion of the ankle the ATFL tightens and since the ATFL is prone to injury often than CFL, this statistical association seen. ((23)(24)

The study predicted patients with partial ATFL rupture have palpated tenderness at AiTFL point without necessarily ruptured AiTFL. A review concluded in the acute lateral sprain local tenderness at AiTFL point doesn't necessarily mean the sign of disrupted AiTFL. But the review concluded if there is no pain at the point of AiTFL it is more unlikely to have syndesmosis disruption, . ((25), compared to this study total ruptured AiTFL verified with the US without palpated tenderness at AiTFL palpated in 2 subjects.

Another study showed with ATFL injuries approximately 40% of patients had pain at AiTFL point. ATFL injury approved with arthroscopy((26).

According to Van Dijk et al ((26)) the clinical examination compared with arthrography results and surgical data the study found 71% sensitivity and 33% specificity for clinical examination on day 2 after an ankle injury and at day 5 after injury 96% and 84%. In the study, the average day of clinical examination was at day 8 with a range of (3-15 days). Our study statistically verified 2 factors that could be predicted; even the mean clinical performance day was on day 8.

A recent correlation study with 34 patients diagnosed lateral sprain and confirmed with US examination approved our study's results. The study concluded no clinical signs of lateral sprain statistically were reliable to predict ligaments tear. ((11)

Our study had some limitations as the examiners skills both in the clinical field and US experience. The study could have been performed differentially if the clinical and the US examination performed blinded by a more experienced doctor and another doctor with a less experience. In the final of the study, a comparison of results could have been calculated.

Even though the US sensitivity and specificity is useful for lateral, AiTFL and Medial ligaments. The US findings could have compared with MRI as golden standard for all ligaments which it has high sensitive and specificity (1)(7).

The study could have described the medial part of ligaments (TC, dpt) US pathological results in details as lateral and AiTFL descriptions and classification.

The study population may not present the background population because the patients that participate in this study may be more aware of their body and may have a different lifestyle than the background population. To minimize the selection bias, the study should have performed when they patient got in the Emergency room. Although the clinical tests would not be possible to perform for many of them.

Another bias in this study was all patient had taken an x-ray of their foot, and no one clinically diagnosed sprain, and the finding of US may present patients with a severe injury. The US finding may be more severe than the backgrounds literature. 3 patients presented with medial abnormalities either in (TC or dPt) but It could be because of the severe group of the sprain, or the examiner unexperienced.

Conclusion:

The study predicted patients with partial rupture of ATFL clinical present with tenderness at AiTFL point and patients presented with intact CFL reported pain during active plantar flexion.

The overall clinical signs and physical examinations were unclear factors to predicate lateral (ATFL, CFL), syndesmosis injuries (AiTFL) and medial ligament injuries compared with the US findings.

The US examination detected other undiagnosed ligament injuries compared with Emergency room even all subjects got an x-ray of their ankle. The next step in this study was to compare the US results with reported symptoms for CLIA in the long term outcome.

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