

# World Journal of *Orthopedics*

*World J Orthop* 2021 September 18; 12(9): 620-726



### MINIREVIEWS

- 620** Coronaviruses: An overview with special emphasis on COVID-19 outbreak with musculoskeletal manifestations  
*Ali S, Singh A, Sharief N, Yadav M, Siddiqui S, Pandey V, Raikwar A, Singh A*
- 629** Hip prosthetic loosening: A very personal review  
*Mjöberg B*
- 640** Jones type fifth metatarsal fracture fixation in athletes: A review and current concept  
*Albloushi M, Alshanqiti A, Qasem M, Abitbol A, Gregory T*
- 651** Effects of sclerostin antibody on bone healing  
*Mihara A, Yukata K, Seki T, Iwanaga R, Nishida N, Fujii K, Nagao Y, Sakai T*
- 660** Current concepts in the management of bisphosphonate associated atypical femoral fractures  
*Rudran B, Super J, Jandoo R, Babu V, Nathan S, Ibrahim E, Wiik AV*
- 672** Virtual orthopedic assessment: Main principles and specific regions  
*Emara KM, Diab RA, Amr M, Mahmoud SA, Nour M, Abdelsalam A, Elshobaky MA, Farhan M, Gemeah M, Emara AK*
- 685** Machine learning in orthopaedic surgery  
*Lalehzarian SP, Gowd AK, Liu JN*

### ORIGINAL ARTICLE

#### Clinical and Translational Research

- 700** Trends and risk factors for opioid administration for non-emergent lower back pain  
*Gwam CU, Emara AK, Chughtai N, Javed S, Luo TD, Wang KY, Chughtai M, O'Gara T, Plate JF*

#### Retrospective Study

- 710** Correlation of stress radiographs to injuries associated with lateral ankle instability  
*Sy JW, Lopez AJ, Lausé GE, Deal JB, Lustik MB, Ryan PM*

### CASE REPORT

- 720** Atypical osteochondroma of the lumbar spine associated with suprasellar pineal germinoma: A case report  
*Suwak P, Barnett SA, Song BM, Heffernan MJ*

**ABOUT COVER**

Editorial Board Member of *World Journal of Orthopedics*, Vasileios S Nikolaou, MD, MSc, PhD, Associate Professor, Surgeon, The Second Orthopaedic Department, School of Medicine, National and Kapodistrian University of Athens, Athens 14233, Greece. vassilios.nikolaou@gmail.com

**AIMS AND SCOPE**

The primary aim of *World Journal of Orthopedics* (*WJO*, *World J Orthop*) is to provide scholars and readers from various fields of orthopedics with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

*WJO* mainly publishes articles reporting research results and findings obtained in the field of orthopedics and covering a wide range of topics including arthroscopy, bone trauma, bone tumors, hand and foot surgery, joint surgery, orthopedic trauma, osteoarthropathy, osteoporosis, pediatric orthopedics, spinal diseases, spine surgery, and sports medicine.

**INDEXING/ABSTRACTING**

The *WJO* is now abstracted and indexed in PubMed, PubMed Central, Emerging Sources Citation Index (Web of Science), Scopus, China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (CSTJ), and Superstar Journals Database. The 2021 edition of Journal Citation Reports® cites the 2020 Journal Citation Indicator (JCI) for *WJO* as 0.66. The *WJO*'s CiteScore for 2020 is 3.2 and Scopus CiteScore rank 2020: Orthopedics and Sports Medicine is 87/262.

**RESPONSIBLE EDITORS FOR THIS ISSUE**

Production Editor: Lin-YuTong Wang; Production Department Director: Xiang Li; Editorial Office Director: Jin-Lai Wang.

**NAME OF JOURNAL**

*World Journal of Orthopedics*

**ISSN**

ISSN 2218-5836 (online)

**LAUNCH DATE**

November 18, 2010

**FREQUENCY**

Monthly

**EDITORS-IN-CHIEF**

Massimiliano Leigheb

**EDITORIAL BOARD MEMBERS**

<http://www.wjgnet.com/2218-5836/editorialboard.htm>

**PUBLICATION DATE**

September 18, 2021

**COPYRIGHT**

© 2021 Baishideng Publishing Group Inc

**INSTRUCTIONS TO AUTHORS**

<https://www.wjgnet.com/bpg/gerinfo/204>

**GUIDELINES FOR ETHICS DOCUMENTS**

<https://www.wjgnet.com/bpg/GerInfo/287>

**GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH**

<https://www.wjgnet.com/bpg/gerinfo/240>

**PUBLICATION ETHICS**

<https://www.wjgnet.com/bpg/GerInfo/288>

**PUBLICATION MISCONDUCT**

<https://www.wjgnet.com/bpg/gerinfo/208>

**ARTICLE PROCESSING CHARGE**

<https://www.wjgnet.com/bpg/gerinfo/242>

**STEPS FOR SUBMITTING MANUSCRIPTS**

<https://www.wjgnet.com/bpg/GerInfo/239>

**ONLINE SUBMISSION**

<https://www.f6publishing.com>

## Retrospective Study

# Correlation of stress radiographs to injuries associated with lateral ankle instability

Joshua W Sy, Andrew J Lopez, Gregory E Lausé, J Banks Deal, Michael B Lustik, Paul M Ryan

**ORCID number:** Joshua W Sy 0000-0002-6578-6003; Andrew J Lopez 0000-0001-5824-6300; Gregory E Lausé 0000-0003-2535-7906; J Banks Deal 0000-0002-5385-4240; Michael B Lustik 0000-0002-8758-5341; Paul M Ryan 0000-0003-2413-2342.

**Author contributions:** Sy JW performed the research; Lausé GE designed the research and contributed to the manuscript and analysis; Lopez AJ performed the research; Deal JB designed the research; Lustik MB performed the statistics review; Ryan PM supervised the report, finalized data analysis and wrote the manuscript.

### Institutional review board

**statement:** This study was reviewed by the Tripler Army Medical Center Institutional Review Board and found to be exempt from IRB review IAW 32 Code of Federal Regulation 219.104(d), category (4)(iii).

### Informed consent statement:

Patients were not required to give informed consent to the study because the analysis used anonymous clinical data.

### Conflict-of-interest statement:

None of the authors have a conflict of interest with the submitted study.

**Joshua W Sy, Andrew J Lopez, Gregory E Lausé, J Banks Deal, Paul M Ryan,** Department of Orthopaedic Surgery, Tripler Army Medical Center, Honolulu, HI 96859, United States

**Michael B Lustik,** Department of Statistics, Tripler Army Medical Center, Honolulu, HI 96859, United States

**Corresponding author:** Gregory E Lausé, MD, MS, Doctor, Department of Orthopaedic Surgery, Tripler Army Medical Center, 1 Jarrett White Rd, Honolulu, HI 96859, United States. [gregory.e.lause.mil@mail.mil](mailto:gregory.e.lause.mil@mail.mil)

## Abstract

### BACKGROUND

Stress radiographs have demonstrated superior efficacy in the evaluation of ankle instability.

### AIM

To determine if there is a degree of instability evidenced by stress radiographs that is associated with pathology concomitant with ankle ligamentous instability.

### METHODS

A retrospective review of 87 consecutive patients aged 18-74 who had stress radiographs performed at a single institution between 2014 and 2020 was performed. These manual radiographic stress views were then correlated with magnetic resonance imaging and operative findings.

### RESULTS

A statistically significant association was determined for the mean and median stress radiographic values and the presence of peroneal pathology ( $P = 0.008$  for tendonitis and  $P = 0.020$  for peroneal tendon tears). A significant inverse relationship was found between the presence of an osteochondral defect and increasing degrees of instability ( $P = 0.043$ ).

### CONCLUSION

Although valuable in the clinical evaluation of ankle instability, stress radiographs are not an independent predictor of conditions associated with ankle in-stability.

**Key Words:** Ankle stress radiographs; Lateral ankle instability; Osteochondral defect;

**Data sharing statement:** Please contact the corresponding author if access to the de-identified data is requested.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Manuscript source:** Invited manuscript

**Specialty type:** Orthopedics

**Country/Territory of origin:** United States

**Peer-review report's scientific quality classification**

Grade A (Excellent): 0  
Grade B (Very good): 0  
Grade C (Good): C  
Grade D (Fair): 0  
Grade E (Poor): 0

**Received:** February 17, 2021

**Peer-review started:** February 17, 2021

**First decision:** May 3, 2021

**Revised:** May 17, 2021

**Accepted:** August 20, 2021

**Article in press:** August 20, 2021

**Published online:** September 18, 2021

**P-Reviewer:** Gantaguru A

**S-Editor:** Wang JL

**L-Editor:** A

**P-Editor:** Ma YJ



Arthroscopy; Peroneal tendinopathy

©The Author(s) 2021. Published by Baishideng Publishing Group Inc. All rights reserved.

**Core Tip:** Ankle Stress Radiographs were predictive of intraoperative findings. Specifically, they may assist the surgeon in clinical decision making regarding osteochondral lesions of the talus and peroneal tendon pathology.

**Citation:** Sy JW, Lopez AJ, Lausé GE, Deal JB, Lustik MB, Ryan PM. Correlation of stress radiographs to injuries associated with lateral ankle instability. *World J Orthop* 2021; 12(9): 710-719

**URL:** <https://www.wjgnet.com/2218-5836/full/v12/i9/710.htm>

**DOI:** <https://dx.doi.org/10.5312/wjo.v12.i9.710>

## INTRODUCTION

Ankle instability is one of the most common sports related injuries with an incidence of 7 per 1000 persons per year[1]. Close to 40% of patients who sustain an inversion injury to their ankle report residual symptoms long after they have recovered from the injury to their lateral ligaments. This residual pain may be secondary to associated conditions that occur at the time of the injury or as a result of chronic instability[2]. The differential diagnosis for associated injuries or causes of residual symptoms is large and includes: occult fractures of the ankle, fractures of the metatarsals, peroneal tendon tears, osteochondral lesions of the talus (OLT), tarsal coalitions, neurogenic injuries, radicular pain, autonomic dysreflexia, impingement, syndesmotic injuries, and subtalar instability. Determining which symptoms are related to ligamentous injury and which symptoms are related to associated conditions can be a diagnostic dilemma. Clinicians use multiple resources to determine which patients have symptoms secondary to ligamentous instability at the tibiotalar joint *vs* symptoms related to other causes. Plain radiographs are often the first modality utilized and radiographs of the ankle and foot can rule out fractures. Unless there is frank instability, a superior retinaculum avulsion, or a large osteochondral fracture, static radiographs do not provide much information on the integrity of the lateral ligaments or associated conditions. Stress radiographs can provide information on the dynamic stability of the tibiotalar joint are often obtained in the evaluation of ankle instability. Previous studies have demonstrated that stress radiographs are more specific than magnetic resonance imaging (MRI) in the evaluation of ligamentous instability[3]. Ultrasound and MRI have a role in evaluating for associated injuries such as chondral injuries and tendon pathology. While being a highly sensitive modalities, MRI has also been shown to miss 20%-80% of associated injuries[4,5]. It would be ideal to have one imaging study that could assist the surgeon in making the diagnosis of instability and at the same time rule out or rule in associated pathology. Since stress radiographs have demonstrated superior efficacy in the evaluation of ankle instability, the purpose of this study is to determine if there is a degree of instability evidenced by stress radiographs that is associated with OLTs and peroneal pathology concomitant with ankle ligamentous instability.

## MATERIALS AND METHODS

A retrospective review of consecutive patients aged 18-74 who had stress radiographs performed at a single institution between 2014 and 2020 was performed. Once the patients with documented stress radiographs were identified, the electronic medical record was utilized to collect the following information: degree of widening on the talar tilt stress radiograph, millimeters of anterior translation on the anterior drawer stress radiograph, presence of an OLT on MRI or noted in the operation report if an operation was performed, presence of a peroneal tendon tear or tendonitis noted on the MRI or in the operation report, and documentation of operative management of an OLT or peroneal tendon. All patients who had a stress radiograph performed were

included in the study. The presence of operative instability was not an inclusion or exclusion criteria.

Stress radiographs were performed manually. Although various providers performed the radiographs, the technique was standardized. An example of a stress radiograph is seen in [Figure 1](#). An initial mortise film was obtained prior to the talar tilt stress view. Once the mortise was aligned, the tibia was held to maintain the mortise while an inversion force was applied to the ankle. Verification of an appropriate mortise view was obtained. The anterior drawer was obtained by first verifying that a perfect lateral of the talus was visible on digital radiography. The tibia was then held in the same alignment and an anterior force was applied to the calcaneus. Verification of the lateral was obtained. All stress radiographs were routinely measured by a board-certified radiologist unaffiliated with the study. An example of the technique utilized to measure the stress radiographs is demonstrated in [Figure 2](#).

The associated findings to include OLTs and peroneal pathology were determined from the MRI reports and operative reports. All MRI reports were read by board certified radiologists unaffiliated with the study. Operative findings were obtained from the dictated operation reports. Because continuous data were not normally distributed, statistical analysis was performed with a nonparametric Wilcoxon Rank Sum Test to assess differences in median levels of anterior drawer and talar tilt angle between patients with and without selected outcomes. All analyses were conducted using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC, United States).

## RESULTS

There were 87 patients meeting inclusion criteria including 14 females and 73 males. The mean talar tilt was  $8.6^\circ$  (range 0-25). The mean anterior drawer was 4.6 mm (range 0-9.9 mm). Peroneal tendonitis was documented in 22 patients (25%). Peroneal tendon tears were documented in 6 patients (7%). An OLT of any size was documented in 42 patients (48%). An OLT greater than 1 cm in its largest diameter was documented in 16 patients (18%). Operative management of an OLT to include microfracture or chondroplasty was performed in 35 patients (40%). Cartilage restoration with Biocartilage or DeNovo NT allograft was performed in 7 patients (8%). An operative exploration of the peroneal tendons was performed in 19 patients (22%). A peroneal tendon repair was required in 2 patients (2%). A lateral ligament repair or modified Broström procedure was performed in 64 patients (74%).

In order to evaluate the relationship between associated findings and stress view values, unpaired *t*-tests were utilized to evaluate mean differences in anterior drawer and talar tilt between patients with and without selected outcomes. There were no statistical associations based upon the anterior drawer as depicted in [Table 1](#). By contrast, the talar tilt angle was associated with several outcomes. Patients with the diagnosis of peroneal tendonitis had a larger talar tilt on average than patients without peroneal tendonitis (mean =  $11.8^\circ$  vs  $7.5^\circ$ ,  $P = 0.004$ ). Similarly, patients with peroneal tears also had larger tilt angles on average than those without tears (mean =  $13.8^\circ$  vs  $8.2^\circ$ ,  $P = 0.026$ ). The remainder of associations are depicted in [Table 2](#).

Tables 3 and 4 summarize results of nonparametric analyses to assess differences in median levels of anterior drawer and talar tilt, respectively, between patients with and without selected reasons for surgery. For anterior drawer, the evaluation shows an inverse relationship found between the degree of instability as measured on the anterior drawer image and the presence of an OLT. Patients who had an OLT had a median anterior drawer of  $4.1^\circ$ , while patients without an OLT had an anterior drawer measurement of  $5.1^\circ$ ,  $P = 0.035$ .

For talar tilt, several significant findings are noted. Larger degrees of tilt were seen in patients who had peroneal tendonitis or peroneal tendon tears, and an inverse relationship was found between the degree of instability and the presence of an OLT. Patients with an OLT had a median talar tilt of  $6^\circ$  while patients without an OLT had a median talar tilt of  $9^\circ$ ,  $P = 0.039$ . Large OLTs were evaluated separately from all OLTs and patients who had a large OLT of greater than 1 cm in diameter were found to have a talar tilt median of  $3^\circ$  while patients who did not have a large OLT were found to have a talar tilt of  $8^\circ$ ,  $P = 0.025$ . As the senior surgeon utilized  $9^\circ$  of instability as an operative indication for a lateral ligament repair or Broström procedure, the data set confirms that selection criteria when utilizing both the mean and median values.

For each area of pathology that had a significant difference found for the mean or median values on stress radiographs, predictive statistics were performed to include



**Table 1 Anterior drawer (mean  $\pm$  SD)**

Outcome	Outcome = No			Outcome = Yes			P value
	n	mean	SD	n	mean	SD	
Peroneal tendonitis	65	4.5	2.7	22	4.9	3.2	0.533
Peroneal tear	81	4.7	2.7	6	3.4	4.0	0.251
MRI OLT	45	5.0	3.0	42	4.2	2.5	0.206
MRI OLT < 1 cm	61	4.9	2.9	26	3.9	2.4	0.107
MRI > 1 cm	71	4.6	2.9	16	4.8	2.6	0.791
Broström	23	4.7	2.2	64	4.6	3.0	0.805
Operative peroneal exploration	68	4.7	2.8	19	4.4	2.8	0.675
Operative peroneal repair	85	4.6	2.8	2	5.8	1.7	0.548
Operative OLT microfracture/chondroplasty	52	5.1	2.8	35	3.9	2.7	0.066
Operative OLT restoration/repair	80	4.6	2.9	7	4.9	1.8	0.753

MRI: Magnetic resonance imaging; OLT: Osteochondral lesions of the talus.

**Table 2 Tilt angle (mean  $\pm$  SD)**

Outcome	Outcome = No			Outcome = Yes			P value
	n	mean	SD	n	mean	SD	
Peroneal tendonitis	65	7.5	5.4	22	11.8	6.7	0.004
Peroneal tear	81	8.2	6.0	6	13.8	4.4	0.026
MRI OLT	45	9.8	6.0	42	7.3	5.8	0.051
MRI OLT < 1 cm	61	8.8	6.3	26	8.1	5.4	0.610
MRI > 1 cm	71	9.2	5.8	16	6.0	6.4	0.057
Broström	23	3.3	3.3	64	10.5	5.6	< 0.001
Operative peroneal exploration	68	8.3	6.0	19	9.7	6.0	0.372
Operative peroneal repair	85	8.6	6.0	2	10.0	8.5	0.739
Operative OLT microfracture/chondroplasty	52	9.1	6.2	35	7.8	5.8	0.339
Operative OLT restoration/repair	80	9.0	6.0	7	4.4	4.9	0.057

MRI: Magnetic resonance imaging; OLT: Osteochondral lesions of the talus.

sensitivity (Sn), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV). The results of this analysis are listed in Tables 5 and 6. Initial analysis of the talar tilt was performed using 10° as the threshold value as seen in Table 5. Given the significant inverted association demonstrated for OLTs and the anterior drawer stress radiograph, predictive analysis was performed for the anterior drawer test utilizing 5° as the threshold as seen in Table 6. Predictive statistics were not performed for the Broström procedure as the surgical candidates were selected largely based upon the stress radiographic results which resulted in the significant association between the Broström procedure and larger values on stress radiographs. In addition, predictive statistics were not performed for OLTs as a significant inverse relationship was demonstrated.

## DISCUSSION

The lateral ligaments of the tibiotalar joint do not provide stability to the joint in isolation. The bony architecture of the tibiotalar joint contributes to its stability with

**Table 3 Anterior drawer median and inter quartile range**

Outcome	Outcome = No			Outcome = Yes			P value
	n	Median	IQR	n	Median	IQR	
Peroneal tendonitis	65	4.5	3.0-6.6	22	4.8	4.0-7.0	0.487
Peroneal tear	81	4.6	3.3-7.0	6	2.1	0.0-7.0	0.318
MRI OLT	45	5.2	2.7-7.5	42	4.3	3.0-5.6	0.110
MRI OLT < 1 cm	61	5.1	3.3-7.1	26	4.2	3.0-5.0	0.062
MRI > 1 cm	71	4.6	2.7-7.0	16	4.7	3.7-6.9	0.891
Broström	23	4.7	4.0-6.9	64	4.5	2.4-7.1	0.870
Operative peroneal exploration	68	4.9	3.3-6.9	19	4.3	2.7-7.0	0.550
Operative peroneal repair	85	4.5	3.0-7.0	2	5.8	4.6-7.0	0.514
Operative OLT microfracture/chondroplasty	52	5.1	3.7-7.2	35	4.1	2.7-5.6	0.035
Operative OLT restoration/repair	80	4.5	2.9-7.0	7	4.8	4.0-6.9	0.827

MRI: Magnetic resonance imaging; OLT: Osteochondral lesions of the talus; IQR: Inter quartile range.

**Table 4 Tilt angle median and inter quartile range**

Outcome	Outcome = No			Outcome = Yes			P value
	n	Median	IQR	n	Median	IQR	
Peroneal tendonitis	65	7	3-12	22	12	6-18	0.008 <sup>1</sup>
Peroneal tear	81	8	3-12	6	15	10-16	0.020 <sup>1</sup>
MRI OLT	45	9	5-14	42	6	2-13	0.043 <sup>1</sup>
MRI OLT < 1 cm	61	8	3-14	26	8	3-13	0.763
MRI > 1 cm	71	8	4-13	16	3	1-10.5	0.025 <sup>1</sup>
Broström	23	3	1-4	64	10	6.5-14	< 0.001 <sup>1</sup>
Operative peroneal exploration	68	8	3-12	19	11	4-15	0.318
Operative peroneal repair	85	8	3-13	2	10	4-16	0.670
Operative OLT microfracture/chondroplasty	52	8	4-13	35	7	3-13	0.360
Operative OLT restoration/repair	80	8	3.5-13	7	3	1-6	0.039 <sup>1</sup>

<sup>1</sup>Significant difference. MRI: Magnetic resonance imaging; OLT: Osteochondral lesions of the talus; IQR: Inter quartile range.

the talus widest anteriorly making the joint most stable in dorsiflexion[6]. In plantar-flexion, the fibula internally rotates and moves inferiorly to maintain the stability of the mortise[7]. In addition to the syndesmotric ligaments, the tibiotalar joint is constrained medially by the deltoid ligamentous complex and laterally through the collateral ligament complex. Dynamic stability of the tibiotalar joint is provided by the surrounding extrinsic musculature. The tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneal tertius contribute to dorsiflexion in the anterior compartment. Within the compartment, the tibialis anterior and extensor hallucis longus also contribute to inversion. This is balanced by the peroneal tertius which provides eversion in addition to dorsiflexion. In the lateral compartment, the peroneal longus and brevis both contribute to eversion which helps to mitigate inversion stresses across the ankle. Posteriorly, the tibialis posterior, flexor digitorum longus, and flexor hallucis longus all help to produce ankle inversion in conjunction with plantar flexion due to the oblique rotational axis of the tibiotalar joint[6].

Given that the lateral ligaments do not provide stability to the ankle in isolation, it follows that the lateral ligaments are not injured in isolation. Clinical studies have demonstrated that that ankle instability occurs with associated pathology such as



**Table 5 Initial analysis of the talar tilt**

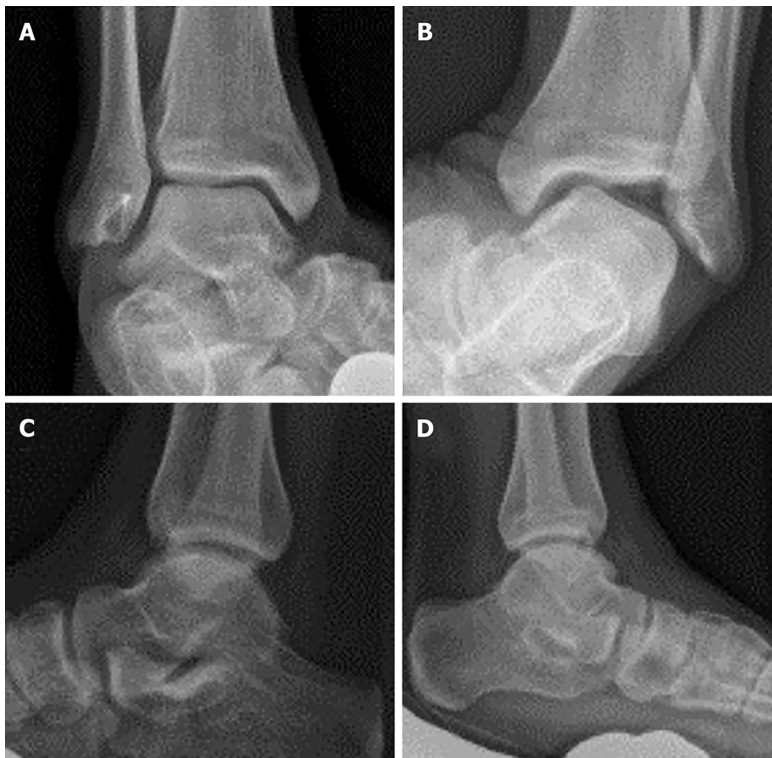
	Talar tilt $\geq 10^\circ$	Talar tilt $< 10^\circ$	Sn (%)	Sp (%)	PPV (%)	NPV (%)
Peroneal tendonitis	13/35	9/52	59	66	37	83
Peroneal tear	5/35	1/52	83	63	14	98
Any peroneal pathology	14/35	10/52	58	67	40	81
Any OLT	15/35	27/52	36	56	43	48

The sensitivity, specificity, positive predictive value, and negative predictive value are documented for the presence or absence of peroneal pathology in relationship to the talar tilt stress radiograph. Note that given the significant inverse relationship found between osteochondral lesions of the talus and stress radiographs, the predictive statistics were inverted as well utilizing a positive test as being a talar tilt  $< 10^\circ$ . Sn: Sensitivity; Sp: Specificity; PPV: Positive predictive value; NPV: Negative predictive value; OLT: Osteochondral lesions of the talus.

**Table 6 The anterior drawer test**

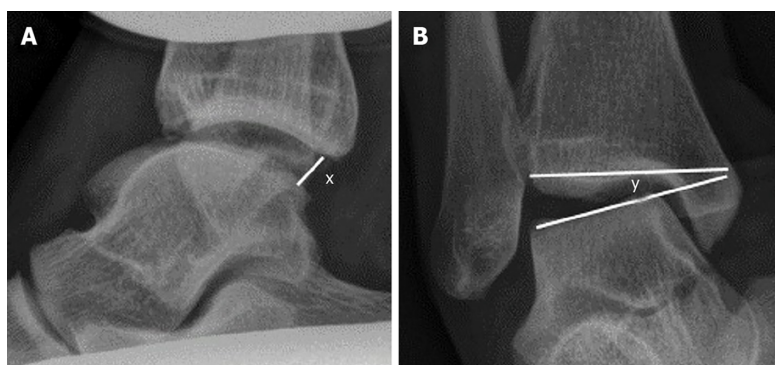
	Anterior drawer $< 5$ mm	Anterior drawer $\geq 5$ mm	Sn (%)	Sp (%)	PPV (%)	NPV (%)
OLT	30	13	70	57	64	68

The sensitivity, specificity, positive predictive value, and negative predictive value are documented for the presence or absence of peroneal pathology in relationship to the anterior drawer stress radiograph. Note that given the significant inverse relationship found between osteochondral lesions of the talus and stress radiographs, the predictive statistics were inverted as well utilizing a positive test as being an anterior drawer  $< 5$  mm. Sn: Sensitivity; Sp: Specificity; PPV: Positive predictive value; NPV: Negative predictive value; OLT: Osteochondral lesions of the talus.



**Figure 1 Stress radiographs.** A: An example of a stable ankle which has previously undergone a modified Broström procedure is depicted; B: The contralateral ankle demonstrating instability on the talar tilt examination is depicted; C and D: The corresponding anterior drawer stress radiographs.

peroneal tendinopathy in up to 28% of cases[8]. Peroneal tendinopathy is considered to be an overuse injury related to inflammatory and degenerative changes[9]. In theory, chronic lateral ligament insufficiency may lead to overuse of the peroneal tendons as the peroneal longus and brevis provide dynamic support to the ankle. Our findings were consistent with this as we found a significant increase in peroneal



**Figure 2** The measurements for stress radiographs are depicted here. A: The anterior drawer distance is obtained by drawing a line from the most posterior aspect of the distal tibial plafond to a point on the talus that is perpendicular to the articular surface of the talus. The distance 'x' is measured in millimeters; B: The anterior drawer is depicted. In order to measure the anterior drawer one line is drawn along the distal articular surface of the tibia and a second line is drawn along the proximal articular surface of the talus. The angle 'y' formed by the intersection of these two lines is the talar tilt angle and is measured in degrees.

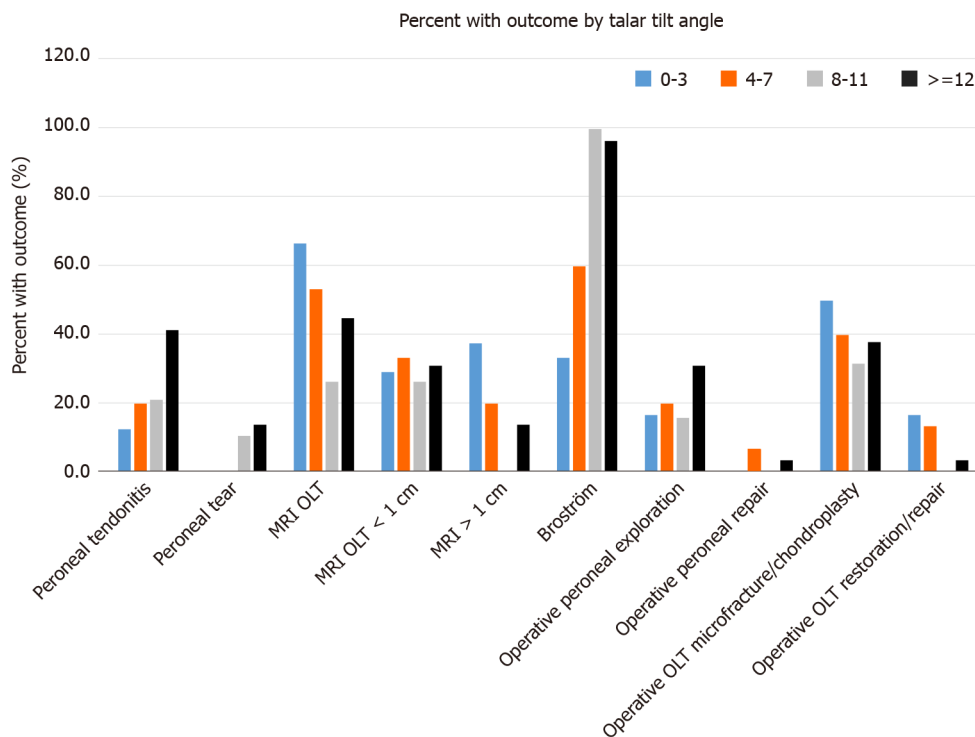
tendonitis in patients who had a talar tilt of  $11.8^\circ$  when compared to patients who had a mean talar tilt of  $7.5^\circ$ .

Split tears of the peroneal brevis tendon are relatively common. A cadaveric study without clinical correlation found a prevalence of split tears in 37.5% of the 112 ankles evaluated[10]. Peroneal muscles are the first muscles to respond and contract in response to ankle inversion[11]. In theory, increasing inversion of an ankle secondary to ligamentous instability could place an increasing strain upon the peroneal tendons. In a review of 180 open ankle lateral ligament repair procedures, Strauss *et al*[8] found 51 (28%) ankles with a peroneal tendon injury. The authors did not further break down the type of injuries found or the treatment provided. Our study found that peroneal tendon tears occurred in patients with a mean talar tilt of  $13.8^\circ$  and was not seen in patients with a mean talar tilt of  $8.2^\circ$ . This data would suggest that increasing degrees of instability may be associated with an increasing incidence of peroneal tendon tears.

Classic imaging studies of peroneal pathology can include plain radiographs, ultrasound, computed tomography (CT), and MRI. Data from plain radiographs is limited in regard to peroneal pathology unless a 'fleck' sign is visualized which is pathognomonic for a superior peroneal retinaculum avulsion. Aside from evaluating associated osseous pathology, CT scan has a limited role in the evaluation of peroneal tendons. Ultrasound is provider dependent but has been shown to accurately predict peroneal tendon tears in 90% of cases[12]. MRI is commonly utilized and can document peroneal tendosynovitis or tears. The artifact that occurs as the tendons curve around the lateral malleolus, however, can decreased the sensitivity to 80% and the specificity to 75%[13].

Although we were able to find an association between larger degrees of instability and the presence of peroneal pathology, we were not able to find a degree of instability that was predictive of instability. Threshold values of 10 mm on the anterior drawer test or  $10^\circ$  on the talar tilt test have been found to correlate with clinical instability[14]. We evaluated the statistical performance of stress radiographs in terms of peroneal pathology. Since the mean talar tilt associated with peroneal tendonitis was  $11.8^\circ$ , and the mean talar tilt associated with a peroneal tendon tear was  $13.8^\circ$ , we evaluated the Sn, Sp, PPV, and NPV of the talar tilt utilizing  $10^\circ$  as the threshold for a positive test for peroneal pathology. We considered a value of 85% to be clinically meaningful given the significant association determined between the mean and medians for each pathology studied. A talar tilt test of  $< 10^\circ$  had a NPV of 98% when evaluating the presence of a peroneal tendon tear in our analysis. The remainder of the values were not found to be clinically meaningful as demonstrated in Table 5.

We also looked at the relationship between OLTs and instability. The tibiotalar joint has a high level of congruency. In plantarflexion and dorsiflexion, the contact surface area of the ankle is decreased and the contact pressures increased[15,16]. Multiple previous studies have suggested an association between increased instability and OLTs. In a study of 148 patients with ankle instability who underwent operative management, Hintermann *et al*[17] found 26 patients (18%) with full thickness cartilaginous lesions of the talus. In a similar study of 65 patients undergoing operative management for lateral ankle instability by Cha *et al*[18], the authors found OLTs in 33 patients (51%). In this study, 22 of these lesions were classified as softening



**Figure 3** The presence of an associated condition is listed next to the number of ankles that have that condition when organized according to the degree of instability as measured on the talar tilt image. MRI: Magnetic resonance imaging; OLT: Osteochondral lesions of the talus.

or superficial fissuring with 20 (18%) being classified as deep fissures or exposed bone [18]. It is unclear as to how many of these lesions required surgical management. In a study of 283 patients requiring surgery for ankle fractures, OLTs were found in 61 patients (73%) during operative arthroscopy. More severe fracture patterns were associated with an increased incidence of OLTs[19]. The association of ankle instability with OLTs, however, has not been consistent in every study. In a recent study, Park *et al*[20] evaluated 195 patients with a history of an inversion injury who were evaluated with both MRI and stress radiographs. The authors defined radiographic instability as having a talar tilt of greater than or equal to 10°. An increased talar tilt was associated with a lower incidence of OLT and the presence of an OLT was associated with a decreased tibiotalar tilt. We found similar findings in our study group. Ankles that did not have an OLT had a mean talar tilt of 9.8° while patients who did have an OLT had a mean talar tilt of 7.3°. When we evaluated our data utilizing the median values rather than the mean to account for outliers, we found a very similar inverse relationship between the presence of an OLT and the degree of instability. We found that the 42 patients who had an OLT had a median talar tilt of 9° while the median talar tilt for the 45 patients who did have an OLT was 6°. As seen in Table 4, this inverse relationship remained significant for larger OLTs and for OLTs that underwent operative management. The inverse relationship in our data set is best depicted in Figure 3. We were not able to find a clinically meaningful value on the anterior drawer test or the talar tilt test in terms of sensitivity, specificity, the positive predictive value, or the negative predictive value. As seen in Table 5, we utilized 10° as the threshold for the talar tilt test. Given the inverse relationship noted for OLTs and instability, a positive test was described as a test having a value of less than 10°. Although a threshold of 10mm has been described for a positive anterior drawer test when evaluating for instability, we utilized a threshold of 5 mm based upon our evaluation of the medians with those patients with an OLT having a median anterior drawer of 3 mm *vs* 8 mm for patients without an OLT. Similar to the talar tilt results, a value of less than 5 mm on the anterior drawer was not predictive of an OLT in our analysis as demonstrated in Table 6.

This study has strengths and weaknesses. We evaluated not just the presence of associated conditions but also documented which conditions were treated surgically. With that said, the presence of conditions on imaging studies or documented during surgery is objective data, while the decision to perform a repair could be subject to bias. The relationship between stress radiographs and functional instability has not been clearly defined. For this reason, we did not evaluate the prevalence of associated

conditions based upon a defined degree of instability but rather evaluated the mean and median instability measured when associated conditions were present. The data confirms the relationship between instability and peroneal pathology demonstrating that patients with peroneal pathology had a significantly higher mean and median talar tilt measurement. In addition, we documented a significant inverse relationship between radiographic instability and the presence of an OLT. This is the second study to evaluate the inverse relationship seen between instability and OLTs.

## CONCLUSION

In evaluating stress radiographs as they relate to associated conditions, we found several areas of significance. Increasing instability was associated with a statistically significant higher prevalence of peroneal tendinopathy and peroneal tendon tears. We also demonstrated an inverse relationship between the presence of OLTs and higher degrees of instability. The broad application of these findings to clinical practice is limited as demonstrated with low sensitivity, specificity, and predictive values for the thresholds measured. Ankle instability remains a complex diagnosis with known associated conditions. While stress radiographs may assist the surgeon in defining mechanical instability, this imaging study alone cannot be utilized to rule out or rule in concomitant pathology that is associated with ankle instability.

## ARTICLE HIGHLIGHTS

### **Research background**

Once patients were diagnosed with instability based upon stress radiographs, the surgical procedure was delayed due to the need to obtain a magnetic resonance imaging in order to define which patients had associated conditions. Prior to this study, the surgeons involved felt that higher degrees on instability were associated with the incidence of associated conditions that could result from instability.

### **Research motivation**

In general, we hoped to avoid a delay in treatment due to the need to obtain advanced imaging. We assumed that patients with higher degrees of instability would have osteochondral lesions or peroneal pathology and would require diagnostic arthroscopy or peroneal exploration while patients with a lesser degree of instability could be addressed with a limited surgical procedure focused on the lateral ligaments.

### **Research objectives**

We aimed to determine a degree of instability that could predict the incidence of peroneal pathology or osteochondral defects.

### **Research methods**

A retrospective analysis of patients who had previously been diagnosed with ankle instability was performed. We stratified the patients based upon their degree of instability as defined by stress radiographs and evaluated the incidence of peroneal pathology and osteochondral defects as related to the varying degrees of instability.

### **Research results**

Increasing degrees of instability was associated with a statistically significant increased prevalence of peroneal pathology. An inverse relationship was found between increasing degrees of instability and the presence of osteochondral defects. While we did confirm the association of ligamentous instability to peroneal pathology and the inverse relationship found between osteochondral defects and instability, we did not find a degree of instability that was predictive of peroneal pathology or osteochondral defects.

### **Research conclusions**

Stress radiographs were not found to be predictive of peroneal tendon pathology or osteochondral defects of the talus.

## Research perspectives

This is only the second study to demonstrate an inverse relationship between ankle instability and osteochondral defects of the talus. This is a novel discovery, but the injury mechanism that leads to ligamentous instability without chondral injury is unclear. Potentially axial load injuries are more likely to result in chondral injuries as opposed to rotational injuries that may lead to ankle instability. Further work is required to better understand this injury pattern.

## REFERENCES

- 1 **Doherty C**, Delahunt E, Caulfield B, Hertel J, Ryan J, Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. *Sports Med* 2014; **44**: 123-140 [PMID: [24105612](#) DOI: [10.1007/s40279-013-0102-5](#)]
- 2 **Freeman MA**. Instability of the foot after injuries to the lateral ligament of the ankle. *J Bone Joint Surg Br* 1965; **47**: 669-677 [PMID: [5846766](#)]
- 3 **Jolman S**, Robbins J, Lewis L, Wilkes M, Ryan P. Comparison of Magnetic Resonance Imaging and Stress Radiographs in the Evaluation of Chronic Lateral Ankle Instability. *Foot Ankle Int* 2017; **38**: 397-404 [PMID: [28061547](#) DOI: [10.1177/1071100716685526](#)]
- 4 **Taljanovic MS**, Alcalá JN, Gimber LH, Rieke JD, Chilvers MM, Latt LD. High-resolution US and MR imaging of peroneal tendon injuries. *Radiographics* 2015; **35**: 179-199 [PMID: [25590397](#) DOI: [10.1148/rg.351130062](#)]
- 5 **O'Neil JT**, Pedowitz DI, Kerbel YE, Coddling JL, Zoga AC, Raikin SM. Peroneal Tendon Abnormalities on Routine Magnetic Resonance Imaging of the Foot and Ankle. *Foot Ankle Int* 2016; **37**: 743-747 [PMID: [26941162](#) DOI: [10.1177/1071100716635645](#)]
- 6 **Brockett CL**, Chapman GJ. Biomechanics of the ankle. *Orthop Trauma* 2016; **30**: 232-238 [PMID: [27594929](#) DOI: [10.1016/j.mporth.2016.04.015](#)]
- 7 **Scranton PE Jr**, McMaster JG, Kelly E. Dynamic fibular function: a new concept. *Clin Orthop Relat Res* 1976; 76-81 [PMID: [954295](#)]
- 8 **Strauss JE**, Forsberg JA, Lippert FG 3rd. Chronic lateral ankle instability and associated conditions: a rationale for treatment. *Foot Ankle Int* 2007; **28**: 1041-1044 [PMID: [17923051](#) DOI: [10.3113/FAI.2007.1041](#)]
- 9 **Aicale R**, Tarantino D, Maffulli N. Overuse injuries in sport: a comprehensive overview. *J Orthop Surg Res* 2018; **13**: 309 [PMID: [30518382](#) DOI: [10.1186/s13018-018-1017-5](#)]
- 10 **Miura K**, Ishibashi Y, Tsuda E, Kusumi T, Toh S. Split lesions of the peroneus brevis tendon in the Japanese population: an anatomic and histologic study of 112 cadaveric ankles. *J Orthop Sci* 2004; **9**: 291-295 [PMID: [15168186](#) DOI: [10.1007/s00776-004-0784-5](#)]
- 11 **Davda K**, Malhotra K, O'Donnell P, Singh D, Cullen N. Peroneal tendon disorders. *EFORT Open Rev* 2017; **2**: 281-292 [PMID: [28736620](#) DOI: [10.1302/2058-5241.2.160047](#)]
- 12 **Grant TH**, Kelikian AS, Jereb SE, McCarthy RJ. Ultrasound diagnosis of peroneal tendon tears. A surgical correlation. *J Bone Joint Surg Am* 2005; **87**: 1788-1794 [PMID: [16085620](#) DOI: [10.2106/JBJS.D.02450](#)]
- 13 **Wang XT**, Rosenberg ZS, Mechlin MB, Schweitzer ME. Normal variants and diseases of the peroneal tendons and superior peroneal retinaculum: MR imaging features. *Radiographics* 2005; **25**: 587-602 [PMID: [15888611](#) DOI: [10.1148/rg.253045123](#)]
- 14 **Chang SH**, Morris BL, Saengsin J, Tourné Y, Guillo S, Guss D, DiGiovanni CW. Diagnosis and Treatment of Chronic Lateral Ankle Instability: Review of Our Biomechanical Evidence. *J Am Acad Orthop Surg* 2021; **29**: 3-16 [PMID: [33347006](#) DOI: [10.5435/JAAOS-D-20-00145](#)]
- 15 **Calhoun JH**, Li F, Ledbetter BR, Viegas SF. A comprehensive study of pressure distribution in the ankle joint with inversion and eversion. *Foot Ankle Int* 1994; **15**: 125-133 [PMID: [7951940](#) DOI: [10.1177/107110079401500307](#)]
- 16 **de Asla RJ**, Wan L, Rubash HE, Li G. Six DOF in vivo kinematics of the ankle joint complex: Application of a combined dual-orthogonal fluoroscopic and magnetic resonance imaging technique. *J Orthop Res* 2006; **24**: 1019-1027 [PMID: [16609963](#) DOI: [10.1002/jor.20142](#)]
- 17 **Hintermann B**, Boss A, Schäfer D. Arthroscopic findings in patients with chronic ankle instability. *Am J Sports Med* 2002; **30**: 402-409 [PMID: [12016082](#) DOI: [10.1177/03635465020300031601](#)]
- 18 **Cha SD**, Kim HS, Chung ST, Yoo JH, Park JH, Kim JH, Hyung JW. Intra-articular lesions in chronic lateral ankle instability: comparison of arthroscopy with magnetic resonance imaging findings. *Clin Orthop Surg* 2012; **4**: 293-299 [PMID: [23205239](#) DOI: [10.4055/cios.2012.4.4.293](#)]
- 19 **Leontaritis N**, Hinojosa L, Panchbhavi VK. Arthroscopically detected intra-articular lesions associated with acute ankle fractures. *J Bone Joint Surg Am* 2009; **91**: 333-339 [PMID: [19181977](#) DOI: [10.2106/JBJS.H.00584](#)]
- 20 **Park BS**, Chung CY, Park MS, Sung KH, Choi Y, Park C, Koo S, Lee KM. Inverse Relationship Between Radiographic Lateral Ankle Instability and Osteochondral Lesions of the Talus in Patients With Ankle Inversion Injuries. *Foot Ankle Int* 2019; **40**: 1368-1374 [PMID: [31452390](#) DOI: [10.1177/1071100719868476](#)]





Published by **Baishideng Publishing Group Inc**  
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

**Telephone:** +1-925-3991568

**E-mail:** [bpgoffice@wjgnet.com](mailto:bpgoffice@wjgnet.com)

**Help Desk:** <https://www.f6publishing.com/helpdesk>

<https://www.wjgnet.com>

