International Journal of Gerontology 16 (2022) 277–280
https://doi.org/10.6890/IJGE.202207_16(3).0021

International Journal of Gerontology

journal homepage: http://www.sgecm.org.tw/ijge/

Original Article

Associated Factors and Healing Process of Injury of the Lateral Malleolus of the Fibula in Lateral Ankle Sprain

Makoto Takahashi [a,b *], Koji Iwamoto [c], Kazuhide Tomita [d], Tomohiko Kamo [a], Shinji Ueda [b], Takeshi Igawa [b], Yukio Miyauchi [b]

[a] *Physical Therapy School of Health Sciences, Japan University of Health Sciences, Saitama, Japan,* [b] *Hitachino Orthopedic Clinic, Ibaraki, Japan,* [c] *Tokyo Professional University of Health Sciences, Tokyo, Japan,* [d] *Ibaraki Prefectural University of Health Sciences, Ibaraki, Japan*

ARTICLE INFO

Accepted 27 December 2021

Keywords:
bony injury,
lateral ankle sprain,
daily living,
older ages,
treatment period

SUMMARY

Background: Lateral ankle sprain is a frequent injury in daily and sports activities. The purpose of this study was to clarify the prevalence and healing process of the lateral malleolus of the fibula fracture in lateral ankle sprains.
Method: We included 57 patients diagnosed with lateral ankle sprain at our clinic between January 2015 and November 2020. The participants were divided into the bony injury (BI) group and the singular ligament injury (LI) group. The analysis parameters were the prevalence rate of BI, age, rest period, treatment period, and cause of injury.
Results: The prevalence of BI was 31.6% (18/57 cases; 17 men and 40 women), with 6 cases of lateral malleolus of the fibula fracture and 12 cases of avulsion fracture. BI was associated with the age of the patients. The age of the BI group (46.8 ± 19.7 years) was significantly higher than that of the LI group (28.4 ± 15.6 years). Moreover, the rest period of the BI group was significantly higher than that of the singular LI group. However, there was no significant difference in the treatment period between the groups. The BI group was significantly more likely to be injured while performing activities of daily living than the LI group.
Conclusion: Patients with BI were older and were more frequently injured in daily living than those with LI. Therefore, aging increases the risk of lateral ankle sprain with BI. This suggests that lateral ankle sprain with bone damage should be treated with less accelerated exercise therapy.

1. Introduction

Ankle sprain is one of the most frequent injuries in daily and sports activities. A previous study reported that the incidence of ankle sprains was one in 10,000,[1] and the number of patients visiting the emergency department due to ankle sprains has been reported to be 302,000 per year.[2] Among ankle sprains, inversion sprains or lateral sprains have a higher injury rate than eversion sprains.[3,4] It has been reported that the anterior talofibular ligament alone is injured in approximately 85% of cases, and the combined anterior talofibular ligament and calcaneofibular ligament is injured in 20–40% of the cases.[2–4]

In general, ankle sprains can be treated with rest, ice, compression, and elevation (RICE), ankle braces, and exercise. Petersen et al.[1] reported that exercises such as neuromuscular training and balance training are effective in treating ankle sprains. Bleakley et al.[5] reported an improvement in activity level after 4 weeks of either standard or functional rehabilitation for grade 1 and 2 ankle sprains. Nevertheless, the previous epidemiological study was limited to ligament injuries and was concerned with the site of injury (lateral or medial ankle sprain), rehabilitation effects, and recovery span. If external forces are applied in the inversion direction and excessive inversion motion is forced, traction stress on the lateral collateral ligament and intra-articular collision of the talus and fibula may cause bony injuries such as lateral malleolus of the fibula fracture and avulsion fracture. However, most previous studies on the pathogenesis of ankle sprains have investigated the ligamentous injury,[2–4] and few studies have focused on complications of ligament and bone injuries. Furthermore, Doherty et al.[6] reported that age, sex, and sports participation are related to the risk of ankle sprain; however, that study did not focus only on lateral ankle sprain but also on comprehensive ankle sprain.

Kobayashi et al.[7] investigated lateral ankle sprain in a systematic review and found that body mass index, eccentric inversion strength, concentric plantar flexion strength, passive inversion joint position sense, and peroneus brevis reaction time were associated with lateral ankle sprain. However, this systematic review focused on single ligament injuries and did not investigate the incidence, factors, or course of treatment for lateral ankle sprains complicated by bone injuries. Severe lateral ankle sprain combined with bony injury is a recurring problem that may cause chronic ankle instability.[6]

The purpose of this study was twofold: first, to clarify the prevalence of lateral ankle sprain with bony injuries and its association with age, sex, and cause of injury (sport or daily injury) using multi-

* Corresponding author. Department of Physical Therapy School of Health Sciences, Japan University of Health Sciences, Saitama, Japan; Department of Rehabilitation, Hitachino Orthopedic Clinic, Ibaraki, Japan.
E-mail address: mtakahashi606@gmail.com (M. Takahashi)

ple logistic analysis; and second, to compare the periods of rest and treatment, sex, and cause of injury between ligament and bony injuries. We hypothesized that the proportion of bony injury in lateral ankle sprains is not a low injury rate and that age, sex, or sport participation are factors that affect the prevalence of this condition.[6] Furthermore, we predicted that there would be no significant difference between ligament[8] and bony injury[9] in terms of the healing process, provided that an appropriate period of rest is ensured.

2. Participants

This study included 57 patients who were diagnosed with ankle sprain with a principal complaint of lateral ankle pain between January 2015 and October 2020 and who subsequently underwent rehabilitation. We excluded patients who were injured in a traffic accident or who had never undergone rehabilitation (Figure 1).

To clarify the treatment process and characteristics of lateral ankle sprain with bony injuries, we selected mature patients with a closed epiphyseal line of the lateral malleolus of the fibula for statistical analysis. The threshold for the occlusion of the epiphyseal line of the patient was determined by an orthopedic surgeon. An orthopedic surgeon, who was a skilled practitioner, diagnosed ankle sprains using X-rays and by performing physical examinations, such as assessment of tenderness and inversion stress tests.

3. Methods

The patients' age, period from injury to start of rehabilitation (rest period), period from injury to end of rehabilitation (treatment period), and causes of injuries (sports injury or daily injury) were investigated using their medical records.

To clarify the factors that contribute to the development of bony injury, multiple logistic analysis was conducted using the stepwise method with the Akaike's Information Criterion, where the dependent variable was the presence of bony injury, and the independent variables were age, sex, and injury activity. Age, rest period, and treatment period were compared between the ligament injury and bony injury groups. To this end, we used the Shapiro-Wilk test to test the normality of the data followed by the two-sample t-test or Mann-Whitney U test as appropriate. We evaluated the association of sex and cause of injury in the ligament injury and bony injury groups, and the Fisher exact test was used when the expected frequency of < 5 was 20%. R Commander software version 4.0.2 was used for statistical processing, and the significance level was set at 5%. This study was approved by the Ethics Committee of Hitachino Orthopedic Clinic (protocol number: 201701). Because this was a retrospective study, there were no adverse events among the patients. Accordingly, the need for informed consent was waived owing to the retrospective nature of the study.

4. Results

The prevalence of bony injury was 31.6% (18/57 cases), with six cases of fracture of the lateral malleolus of the fibula and twelve cases of avulsion fracture (Figure 2). Bony injury was associated with patient age (odds ratio of 1.06, 95% confidence interval: 1.01–1.13) but not with other factors such as sex or injury activity (Table 1). The tenderness points in the 39 patients with singular ligament injury were as follows: anterior talofibular ligament in 22 (56.4%); anterior talofibular ligament/bifurcate ligament in 5 (12.8%); anterior talofibular ligament/calcaneofibular ligament in 4 (10.3%); anterior talofibular ligament/posterior talofibular ligamentin 4 (10.3%); anterior talofibular ligament/deltoid ligament in 2 (5.1%); anterior talofibular ligament/calcaneofibular ligament/posterior talofibular ligament in 1 (2.6%); and anterior talofibular ligament/bifurcate

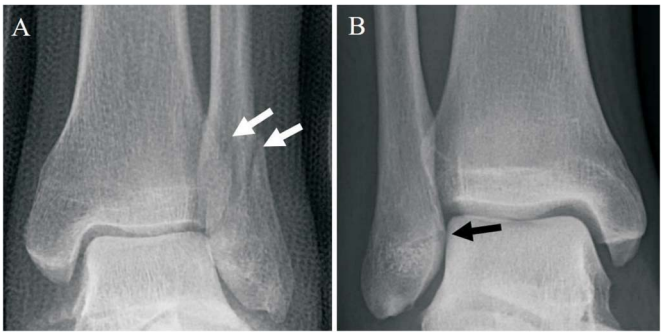

Figure 2. Diagnosis of bony injury. (A) Fibula fracture (white arrow: presence of a bone fragment, left ankle). (B) Avulsion fracture (black arrow: presence of fracture line, right ankle).

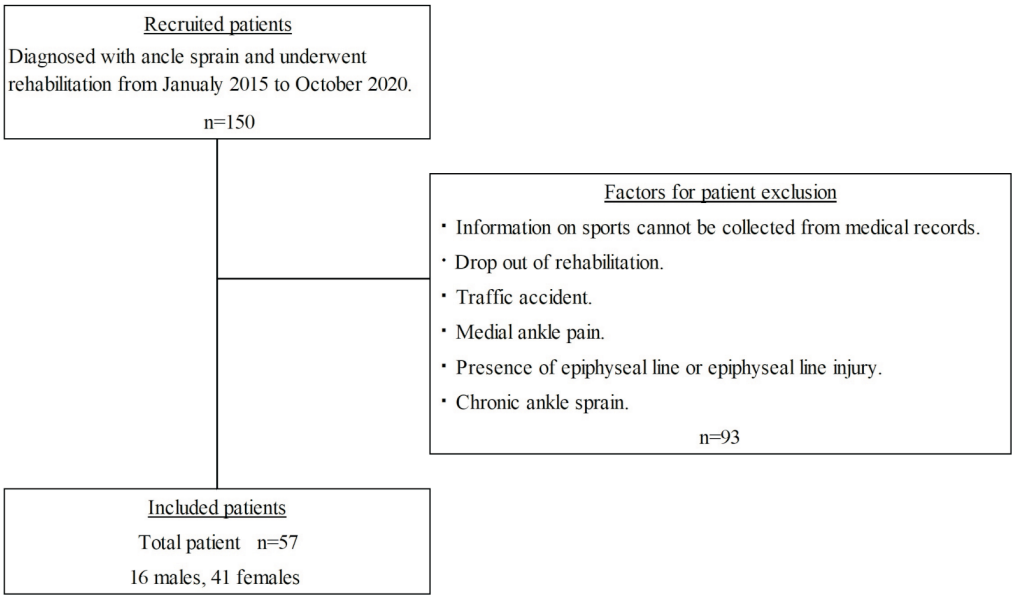

Figure 1. Patients included in the study.

Table 1
Multiple logistic regression analysis of factors related to bony injury.

	Odds ratio (95% CI) Unadjusted model	p-value	Odds ratio (95% CI) Adjusted model	p-value
Age, years	1.06 (1.02–1.10)	0.002**	1.06 (1.01–1.13)	0.048*
Sex				
Male				
Female	0.32 (0.09–1.08)	0.067		
Cause of injuries				
Sports injury				
Daily injury	5.85 (1.79–21.9)	0.005**		

* p < 0.05, ** p < 0.01.

ligament/deltoid ligament in 1 (2.6%).

A comparison of the age, rest period, and treatment period between the bony injury and singular ligament injury groups is presented in Table 2. The age of the bony injury group (46.8 ± 19.7 years) was significantly higher than that of the singular ligament injury group (28.4 ± 15.6 years, $p = 0.001$). Moreover, the rest period of the bony injury group (45.8 ± 28.0 days) was significantly longer than that of the singular ligament injury group (35.0 ± 23.3 days, $p = 0.024$). However, there was no significant difference in the treatment period between the bony injury group (112.2 ± 51.6 days) and the singular ligament injury group (104.9 ± 49.2 days). The bony injury group included subjects with sports injuries (5/18 cases) and of both sexes (8 men and 10 women), while the singular ligament injury group comprised 27/39 cases, of which 8 were men and 31 were women. The subjects in the bony injury group (13/18 cases) were significantly more likely to be injured while performing activities of daily living than subjects in the single ligament injury group (12/39 cases, $p = 0.003$).

The breakdown of injuries in sports and daily life is shown in Figure 3. Sports injuries more frequently occurred while playing basketball and soccer, whereas injuries in daily activities occurred more often during step ascent or descent and while walking.

Table 2
Comparison of age, rest period, rehabilitation period, and treatment period between the bony injury group and singular ligament injury group.

	Total n = 57	LI n = 39	BI n = 18	p-value
Age, years	34.2 ± 18.7	28.4 ± 15.6	46.8 ± 19.7	0.001**
Sex				0.062
Male	16	8	8	
Female	41	31	10	
Cause of injuries				0.003**
Sports injury	32	27	5	
Daily injury	25	12	13	
Rest, days	38.4 ± 24.9	35.0 ± 23.3	45.8 ± 28.0	0.024*
Treatment, days	107.2 ± 49.1	104.9 ± 49.2	112.2 ± 51.6	0.557

* p < 0.05, ** p < 0.01, BI: bony injury group, LI: ligament injury group.

5. Discussion

A previous study[10] reported 51 ankle fractures in 180 patients with ankle sprains, from their magnetic resonance imaging (MRI) examinations. However, this study did not clarify the prevalence of bone damage in ankle sprains and the findings were for any direction ankle sprains, such as inversion, eversion, and combination. Therefore, this study focused on lateral ankle sprain and bony injury, which has not been reported in many previous studies. In the present study, the prevalence of bone injury in the lateral malleolus in ankle sprains was 31.6%. Garrick reported that the proportion of patients with ankle sprains visiting medical institutions was 7–10%.[11] Therefore, the patients in this study may have had severe ankle sprains with a significant decrease in activity level. Moreover, among the parameters considered (age, sex, and sports activities), age was the only one associated with bony injury (odds = 1.06, 95% CL = 1.01–1.13), and the age of the bone injury group was significantly higher than that of the ligament injury group (46 vs. 28 years, $p = 0.001$). Impairment of physical functions, such as peroneal muscle function, proprioception sensation, and balance, may be one of the factors contributing to ankle sprains in older people.[12] With the advance of age, the risk of functional impairment increases, which may result in severe ankle sprain with bony injury.

It has been reported that ankle sprains often occur during sports activities such as basketball, soccer, and volleyball,[1,13] but there are few studies on ankle sprains with bony injuries. From the results of this study, the ligament injury group had a higher incidence of sports injuries, while the bony injury group had a higher incidence of injuries in activities of daily living. Moreover, daily injury occurs more often during step ascent or descent or while walking. With the advance of age, the strength and response of the peroneal muscles that antagonize the ankle inversion are reduced, which may lead to ankle sprain with bony injury.[12] This finding suggests that prevention and treatment of ankle sprains should focus not only on sports activities but also on activities of daily living.

Bleakley et al.[5] indicated that the self-reported function improved sufficiently after 3 months of follow-up for grade 1 and 2 ankle sprains. The results of this study showed that the resting period for bony injury was 7 weeks, which was significantly longer than that for ligament injury. However, there was no significant difference in the period of treatment between the bony injury and ligament injury groups, and the treatment period in this study was 3 or 4 months, similar to previous studies.[5] In this connection, a 7-week rest period may be sufficient to allow the necessary healing process of ligament[8]

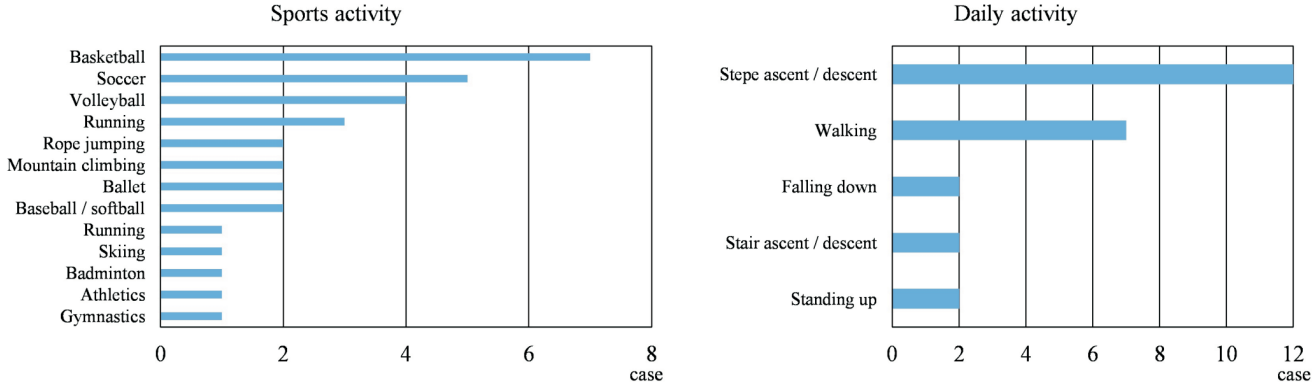

Figure 3. Breakdown of sports injuries (left) and daily living injuries (right).

and bony injuries,[9] which may have contributed to the favorable outcomes in both groups. Wei et al.[14] reported that 33% of patients with ankle sprains had overlooked fractures. Since ligament[8] and bony injuries[9] have a different healing processes, an accurate diagnosis is essential. A diagnosis of bony injury and physical therapy that takes these processes into account may be most convenient. We suggest that although accelerated exercise for ankle sprains is recommended,[8] it should not be applied to lateral ankle sprain with bony injuries.

Our study has some limitations in that the periods of rest and treatment were derived from the medical records of the patients; in the future, subjective and objective indicators should be used. In addition, the results of the logistic analysis showed that age had an effect on bony injury, but the odds ratio was low. Although this study used data from patients with lateral ankle sprain, which is very valuable for focusing on bony injuries, the clinical significance of these finding needs to be confirmed in a larger patient population. Furthermore, although this study focused on lateral ankle sprains, Debieux[10] reported that there is a relationship between a lateral ligament complex injury and medial (deltoid) ligament injury. Therefore, to clarify the number and type of torn ligaments in patients without bony injury, MRIs as well as X-rays and tender points should be examined carefully. Finally, since this was a retrospective study, a cohort study is necessary to clarify the incidence of ankle sprain with bony injury in the future.

6. Conclusion

The results of this study showed that 31.6% of the patients had lateral ankle sprain with bone injury, which was not a low injury rate. The results of our study showed that bone injuries were more common at older ages and were more frequently sustained in daily life. The resting period of the bony injury group was longer than that of the ligament injury group, but the duration of treatment was not significantly different between the two groups. Further, a 7-week rest period may be necessary for the bony healing process, followed by a 3- or 4-month treatment period. We suggest that while an accelerated exercise program is recommended for lateral ankle sprain, an approach that considers the healing process of the injured soft tissues, such as ligaments and bones, is also convenient.

Conflict of interest

The authors declare no conflicts of interest associated with this study.

References

1. Petersen W, Rembitzki IV, Koppenburg AG, et al. Treatment of acute ankle ligament injuries: A systematic review. *Arch Orthop Trauma Surg*. 2013; 133(8):1129–1141.
2. Ferran NA, Maffulli N. Epidemiology of sprains of the lateral ankle ligament complex. *Foot Ankle Clin*. 2006;11(3):659–662.
3. Garrick JG. The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. *Am J Sports Med*. 1977;5(6):241–242.
4. Van den Bekerom MP, Oostra RJ, Golanó P, et al. The anatomy in relation to injury of the lateral collateral ligaments of the ankle: A current concepts review. *Clin Anat*. 2008;21(7):619–626.
5. Bleakley CM, O'Connor SR, Tully MA, et al. Effect of accelerated rehabilitation on function after ankle sprain: Randomised controlled trial. *BMJ*. 2010;340:c1964.
6. Doherty C, Delahunt E, Caulfield B, et al. The incidence and prevalence of ankle sprain injury: A systematic review and meta-analysis of prospective epidemiological studies. *Sports Med*. 2014;44(1):123–140.
7. Kobayashi T, Tanaka M, Shida M. Intrinsic risk factors of lateral ankle sprain: A systematic review and meta-analysis. *Sports Health*. 2016;8(2): 190–193.
8. Galloway MT, Lalley AL, Shearn JT. The role of mechanical loading in tendon development, maintenance, injury, and repair. *J Bone Joint Surg Am*. 2013;95(17):1620–1628.
9. Vigorita VJ, Ghelman B. Fracture Healing/Callus. In: Vigorita VJ, Ghelman B, eds. *Orthopaedic Pathology*. Philadelphia, USA: Lippincott Williams & Wilkins; 1999:90–94.
10. Debieux P, Wajnsztejn A, Mansur NSB. Epidemiology of injuries due to ankle sprain diagnosed in an orthopedic emergency room. *Einstein (Sao Paulo).* 2019;18:eAO4739.
11. Viljakka T, Rokkanen P. The treatment of ankle sprain by bandaging and antiphlogistic drugs. *Ann Chir Gynaecol*. 1983;72(2):66–70.
12. Beynnon BD, Murphy DF, Alosa DM. Predictive factors for lateral ankle sprains: A literature review. *J Athl Train*. 2002;37(4):376–380.
13. Wei CJ, Tsai WC, Tiu CM, et al. Systematic analysis of missed extremity fractures in emergency radiology. *Acta Radiol*. 2006;47(7):710–717.
14. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. *J Athl Train*. 2002;37(4):364–375.