The Anatomic Pattern of Injuries in Acute Inversion Ankle Sprains
A Magnetic Resonance Imaging Study

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Background: There are little data on the incidence and patterns of injuries seen on magnetic resonance imaging (MRI) in acute inversion ankle sprains. This study may help in the understanding of the pathomechanics, natural history, and outcomes of this common injury.

Study Design: Case series; Level of evidence, 4.

Methods: From June 2011 to June 2013, a total of 64 consecutive patients had MRI of the ankle performed for acute inversion injury to the ankle. All injuries/pathologies reported were recorded.

Results: Only 22% of patients had isolated lateral ligament complex injuries. Twenty-two percent of patients had other pathologies but no lateral ligament injury, and 53% had lateral ligament injuries in combination with other pathologies or injuries. The most common associated finding with lateral ligament injuries was bone bruising (76%) followed by deltoid ligament injury (50%). The overall incidence of bone bruising was 50%. Thirty percent of ankles had tendon pathology, 27% had deltoid ligament injury, and 22% had occult fractures.

Conclusion: Isolated lateral ligament ankle injury is not as common as is believed. The pattern of injury seems complex, and most patients appear to have more injuries than expected. MRI reveals additional information that may have significance in terms of diagnosis, treatment, and prognosis in this common injury.

Keywords: ankle; sprain; magnetic resonance imaging; sports injuries

Ankle “sprains” are common injuries. The incidence has been reported to be between 2 and 7 per 1000 person-years. The absolute risk of ankle sprains had been estimated to be 1 per 1000 sports hours and makes up a significant amount of lost playing time. In addition to the loss of sporting time, the cost of treating ankle sprains can be high for the individual and health care systems. It is generally believed that 80% to 90% of ankle ligament injuries involve lateral ligaments, with the anterior talofibular ligament (ATFL) being the most vulnerable. Nonetheless, there may be other associated injuries that are sometimes overlooked or difficult to detect at physical examination. Conventional treatment involves rest, ice, compression, and elevation followed by active range of motion and neuromuscular coordination and peroneal strengthening. However, the optimal length of treatment is unknown, and insufficient rehabilitation of the ankle may result in residual symptoms. Physical examination during the acute situation can be unreliable because of pain. Magnetic resonance imaging (MRI) of the ankle is now an available adjunct to clinical assessment of ankle sprains. Although reports of the sensitivity and specificity of MRI for the diagnosis of ankle sprains have been variable in the literature, it is still a useful tool to identify other occult injuries that would otherwise go unrecognized. MRI is often limited to patients with persistent pain and swelling because of high costs, the high incidence of sprains, and limited resources. As such, most of the available studies on the usefulness of MRI in ankle sprains focus on patients with chronic symptoms. There is little information on the pattern of injury seen on MRI in acute ankle injuries. We aim to report the patterns of injury seen on MRI of the ankle in patients presenting with acute inversion ankle sprains. We believe that MRI is likely to identify many occult or unexpected injuries.

METHODS

This study was performed with the approval of our local institutional review board. For the purpose of this study, all patients presenting to a single foot and ankle surgeon’s clinic from June 2011 to June 2013 with ankle sprains were
reviewed. It was the surgeon’s routine practice to offer an MRI scan of the ankle to all patients who presented to his clinic with ankle sprains.

We retrospectively selected 64 consecutive patients from the radiology archives. The medical records were reviewed for the mechanisms of ankle injuries and time of injury to MRI scan. Only patients who reported inversion injury to the ankle and also had MRI of the ankle within 3 months of injury were selected for this series. The formal MRI reports were reviewed, and all reported findings, including that of sprains, partial and complete ligament tears, bone edema, fractures, tendonitis, tendon tears, syndesmosis injury, and osteochondral lesions were recorded into an Excel (Microsoft Corp, Redmond, Washington, USA) database. Anterior inferior tibiofibular ligament injuries were included in the syndesmosis injury group. We excluded patients who had radiographic evidence of fracture, including flake-like avulsion fractures, prior ankle surgery, or chronic ankle pathology.

RESULTS

The mean age of the 64 patients (55 males, 9 females; 33 right ankles) was 25 years (range, 13-49 years). The mechanisms of injury were sporting activities (n = 35; 54.6%), walking (n = 18; 28.1%), fall (n = 9; 14.1%), and road traffic accidents (n = 2; 3.1%). The median time from injury to MRI was 6 weeks (range, 4 days to 12 weeks). Only 14 patients (22%) had isolated lateral ligament complex injuries. Fourteen patients (22%) had other injuries but no lateral ligament injury. Thirty-four patients (53%) had lateral ligament injury and other concomitant injuries (Table 1). The overall incidences of the MRI findings are listed in Table 2.

Lateral Ligament Injury

Forty-eight patients (75%) had injury to the ATFL, 26 (41%) had injury to both ATFL and calcaneofibular ligament (CFL), and 3 (5%) had posterior talofibular ligament (PTFL) injury. Thirty-four of the 48 patients (71%) with lateral ligament injury also had other concomitant findings on MRI (Table 3). The most common associated finding was bone bruising (26/34; 76%), followed by deltoid injury (17/34; 50%). Nine of 34 patients (26%) had lateral ligament injury and 1 other concomitant finding, 15 patients (44%) had 2 other findings, 5 (15%) had 3 other findings, and 5 (15%) had 4 other findings.

Other Pathology

Overall, 32 patients (50%) had bone bruising, 19 (30%) had tendon pathology, and 14 (22%) had fractures. One patient had ATFL tear and obliteration of sinus tarsi fat. Twelve patients (19%) did not have lateral ligament complex injuries but had other findings on MRI. The locations of the fractures are illustrated in Table 4. The overall incidence of fracture was 22%, of which 13% were avulsion-type fractures and 9% were non-avulsion-type.

DISCUSSION

Ankle sprains are common injuries, particularly in young individuals participating in sports. However, rather surprisingly, little is known with regard to the best diagnostic techniques, management, and outcomes. There are even less data on the patterns of injury seen on MRI when performed in acute ankle sprains. In the management of ankle sprains, most would advise conservative management, the duration of which is variable, while advanced imaging is

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**TABLE 1**

| MRI Finding                                      | n (%) |
|-------------------------------------------------|-------|
| Normal                                           | 2 (3.1) |
| Lateral ligament injury only                     | 14 (21.8) |
| ATFL only                                        | 9 |
| ATFL + CFL                                       | 5 |
| No lateral ligament injury but other findings    | 14 (21.8) |
| Lateral ligament injury + other findings         | 34 (53.1) |
| Total                                           | 64 (100) |

*ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament.

**TABLE 2**

| MRI Finding                                      | n | Incidence, % |
|-------------------------------------------------|---|--------------|
| ATFL injury                                     | 48 | 75 |
| Bone bruise                                     | 32 | 50 |
| CFL injury                                      | 26 | 41 |
| Tendon pathology                               | 19 | 30 |
| Deltoid injury                                  | 17 | 27 |
| Fracture                                        | 14 | 22 |
| Osteochondral lesion                           | 9  | 14 |
| Syndesmosis injury                              | 5  | 8  |
| PTFL injury                                     | 3  | 5  |
| Sinus tarsi change (obliteration of fat signal) | 1  | 2  |

*ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; PTFL, posterior talofibular ligament.

**TABLE 3**

| Associated Injury                      | n | Incidence, % |
|----------------------------------------|---|--------------|
| Bone bruise                            | 26 | 76 |
| Deltoid injury                         | 17 | 50 |
| Tendon injury                          | 11 | 32 |
| Fracture                               | 10 | 29 |
| Osteochondral lesion                   | 6  | 18 |
| Syndesmosis injury                     | 2  | 6  |
| Sinus tarsi change                     | 1  | 3  |

34; 50%). Nine of 34 patients (26%) had lateral ligament injury and 1 other concomitant finding, 15 patients (44%) had 2 other findings, 5 (15%) had 3 other findings, and 5 (15%) had 4 other findings.
usually only offered to those with persistent symptoms. Ankle sprains are most commonly inversion injuries with supination and plantar flexion of the foot and external rotation of the tibia. They are classified as grades 1 through 3 in order of severity. In grade 1 injuries, there is stretch to the ligament with no increase in laxity; grade 2, macroscopic rupture with some increased laxity; and grade 3 indicates complete rupture. However, this grading system concentrates on the severity of the injury to the lateral ligaments, with no focus on the possibility of other concomitant injuries.

Clinical assessment in the acute setting may not be reliable as it may be limited by pain. Frey et al evaluated 15 patients with inversion injuries to the ankle who had MRI within 48 hours of injury and found physical examination to be only 25% accurate in the diagnosis of grade 2 injuries. They found that clinicians often underestimate the damage with grade 2 ligament tears. Treatment options include rest, early mobilization, immobilization, or surgical repair of torn ligaments. However, it has been estimated that between 30% and 74% of patients with injuries of the ankle ligaments have residual symptoms of pain or instability regardless of treatment, suggesting that perhaps other factors or associated injuries may have an impact on outcome. This remains a controversial topic at present. Although a high proportion of patients with ankle sprains have residual symptoms, most returned to sports or work within 3 months.

In our series of patients, only 22% had isolated lateral ligament injury, whereas 53% also had concomitant pathologies on MRI. The most common associated finding was bone bruising. Bone bruises are thought to represent trabecular microcontusions. Their significance and natural history in the ankle, unlike the knee where they tend to resolve in 1 to 4 months after injury, is unknown. In the ankle, bone bruises may persist beyond this period, suggesting that increased time may be needed for their healing. In addition, whether bone bruises develop into subsequent osteochondral pathology remains unknown. Although bone bruises are often associated with ligamentous injury, they have been found to be more common in runners suggesting that, under these circumstances, bone bruises may also be caused by exercise. The incidence of ankle sprains has been reported to be between 7% and 40%. The incidence of bone bruises in this series (50%) was consistent with the reported literature. There appears to be an increased frequency of bone bruises in ankles with multiple ligament injuries. In a series of 54 patients where approximately half did not have ligament injury on MRI, Yammine and Fathi suggested that isolated bone bruise and tendon injury may present with similar clinical signs as ankle sprains. We found 1 randomized controlled trial evaluating the significance of bone bruises and clinical outcome. In this series of 95 patients, 27% of patients had bone bruises but they did not affect clinical outcome, time to return to work, or mobility at 3 months. The significance of bone bruises found on MRI and whether they require treatment or follow-up remains unknown.

Deltoid ligament sprains were also common in this series, with an overall incidence of 27%. In the subgroup of patients with MRI evidence of lateral ligament injury, the incidence of deltoid injury was 35%. Deltoid ligament injuries occurred in 50% of patients with lateral ligament injuries in combination with other pathologies. The deltoid ligament is an important medial structure that plays a role in preventing ankle eversion and some degree of external rotation. The position of the foot appears to have a role in injuries sustained during sprains. Damage to the deltoid ligament is believed to be a result of an external rotation force to the foot. One cadaveric study evaluating external rotation force in a neutral or everted foot with the ankle in dorsiflexion found that deltoid ligament injury is more likely when the foot was in neutral while a similar force is likely to damage the syndesmosis in the everted foot. Injury to the deltoid ligament has been found to be present in patients with chronic ankle instability who may or may not present with symptoms of medial pain. The incidence of deltoid ligament injury was found to be 68% in patients who underwent lateral ligament surgery for chronic instability noted in their preoperative MRI.

### TABLE 4
**Location of Occult Fractures Recorded on MRI**

| Patient | Laterality | Sex | Age, y | Mechanism of Injury | Time From Injury to MRI | Fracture Location |
|---------|------------|-----|--------|---------------------|------------------------|-------------------|
| 1       | Left       | Male| 17     | Walking             | 10 days                | Distal tibia medial epiphysis extending into physeal plate |
| 2       | Right      | Male| 20     | Sports injury       | 6 weeks                | Avulsion fracture of talus at deltoid insertion |
| 3       | Right      | Male| 22     | Sports injury       | 9 weeks                | Avulsion fracture medial malleolus |
| 4       | Right      | Male| 21     | Walking             | 4 weeks                | Avulsion fracture lateral malleolus |
| 5       | Left       | Male| 28     | Sports injury       | 5 weeks                | Lateral tibia plafond fracture |
| 6       | Right      | Male| 19     | Fall                | 7 weeks                | Avulsion fracture of lateral malleolus and deltoid attachment |
| 7       | Left       | Male| 45     | Sports injury       | 12 weeks               | Avulsion fracture of lateral malleolus |
| 8       | Right      | Male| 27     | Fall                | 4 weeks                | Avulsion fracture of medial malleolus |
| 9       | Right      | Male| 30     | Sports injury       | 12 weeks               | Fracture of navicular |
| 10      | Right      | Male| 49     | Walking             | 4 weeks                | Fracture of cuboid |
| 11      | Right      | Female| 24  | Walking             | 5 weeks                | Third metatarsal base fracture |
| 12      | Right      | Male| 19     | Sports injury       | 2 weeks                | Avulsion fracture of lateral malleolus |
| 13      | Right      | Female| 38   | Walking             | 8 weeks                | Avulsion fracture of lateral malleolus |
| 14      | Right      | Male| 20     | Sports injury       | 8 weeks                | Avulsion fracture of lateral malleolus |
et al.\textsuperscript{9} performed arthroscopic evaluation of 148 chronically unstable ankles and found the incidence of deltoid injury to be about 40\%, and all of these patients had damage to the lateral ligament complex. About one third of these patients reported symptoms on the medial aspect of the foot or ankle. The incidence of deltoid ligament injury in acute “sprains” in our study matches these 2 studies of patients with chronic ankle instability. Interestingly, the incidence of deltoid ligament injury in our study is similar to the incidence of residual pain and instability in outcome studies of ankle sprains. We do not know the significance of our findings. At present, there are no guidelines for the management of deltoid injuries in the absence of fracture. There is a possibility that damage to the deltoid ligament could serve as a predictor of future instability, and this group of patients may require closer follow-up and/or a longer duration of protected mobilization. A better understanding of the role of the deltoid ligament in ankle stability may also facilitate strategies designed to prevent chronic instability.

Patients who present with ankle sprains with normal radiographs may have occult fractures of the ankle and foot. The incidence of osseous injuries in patients presenting with ankle sprains based on radiographs have been reported between 4.6\% and 14.4\%.\textsuperscript{6,22} Sujitkumar et al.,\textsuperscript{22} in a review of 1600 patients presenting with all ankle injuries, found the incidence of minor flake fractures to be 4.6\%. Another study of 639 patients presenting with ankle sprains found the incidence of fractures to be 14.4\%.\textsuperscript{4} This group excluded ankle fractures apart from avulsion fractures. Both these studies used radiography to evaluate injuries in the ankle and foot. The use of MRI could explain the higher incidence of fractures reported in our study. We did not find any other studies evaluating the incidence of fractures with the use of MRI in ankle sprains.

Our study has limitations. First, it is a retrospective study with a small sample size. There was a substantial range of time from injury to MRI because of delays between presentation to the emergency department, review by the foot and ankle specialist, and time to obtain outpatient MRI. We felt that the mean time of 6 weeks from injury to MRI was a reasonable criterion for acute injuries. In addition, the MRI imaging protocol was not standardized, and the scans were read by different radiologists. It would have been meaningful to perform correlation studies between MRI findings and clinical outcome; however, this was not the aim of our study.

CONCLUSION

The role of early MRI in acute inversion ankle sprains and the significance of the injury patterns remain unclear. The results of this study indicate that ankle sprains may not be as simple as believed. There are many questions yet to be answered in the diagnosis and management of this common injury. More research is needed to correlate the MRI findings to the clinical presentation, natural history, and outcomes of treatment for inversion ankle injuries.

REFERENCES

1. Alalen V, Taimela S, Kinnunen J, Koskinen SK, Karaharju E. Incidence and clinical significance of bone bruises after supination injury of the ankle. A double-blind, prospective study. \textit{J Bone Joint Surg Br.} 1998; 80:513-515.
2. Anandacoomarasamy A, Barnsley L. Long term outcomes of inversion ankle injuries. \textit{Br J Sports Med.} 2005;39:e14.
3. Breitenseher MJ, Trattnig S, Kukla C, et al. MRI versus lateral stress radiography in acute lateral ankle ligament injuries. \textit{J Comput Assist Tomogr.} 1997:21:280-285.
4. Bridgman SA, Clement D, Downing A, Walley G, Phair I, Maffulli N. Population based epidemiology of ankle sprains attending accident and emergency units in the West Midlands of England, and a survey of UK practice for severe ankle sprains. \textit{Emerg Med J.} 2003:20:508-510.
5. Crim JR, Beals TC, Nickisch F, Schannen A, Saltzman CL. Deltoid ligament abnormalities in chronic ankle instability. \textit{Foot Ankle Int.} 2011;32:873-878.
6. Fallat L, Grimm DJ, Saracco JA. Sprained ankle syndrome: prevalence and analysis of 639 acute injuries. \textit{J Foot Ankle Surg.} 1998; 7:280-285.
7. Frey C, Bell J, Teresi L, Kerr R, Feder K. A comparison of MRI and clinical examination of acute lateral ankle sprains. \textit{Foot Ankle Int.} 1996; 17:533-537.
8. Garrick JG. The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. \textit{Am J Sports Med.} 1977;5:241-242.
9. Hintermann B, Boss A, Schafer D. Arthroscopic findings in patients with chronic ankle instability. \textit{Am J Sports Med.} 2002;30:402-409.
10. Holmer P, Sondergaard L, Konradsen L, Nielsen PT, Jorgensen LN. Epidemiology of sprains in the lateral ankle and foot. \textit{Foot Ankle Int.} 1994;15:72-74.
11. Hupperets MD, Verhagen EA, Heymans MW, Bosmans JE, van Tulder MW, van Mechelen W. Potential savings of a program to prevent ankle sprain recurrence: economic evaluation of a randomized controlled trial. \textit{Am J Sports Med.} 2010;38:2194-2200.
12. Karlsson J, Rolf C, Orava S. Lower leg, ankle and foot. In: Kjaer M, Krogsgaard M, Magnusson P, et al, eds. \textit{Textbook of Sports Medicine: Basic Science and Clinical Aspects of Sports Injury and Physical Activity.} Malden, MA: Blackwell Science; 2003:540-560.
13. Kumar V, Triantafyllopoulos I, Panagopoulos A, Fitzgerald S, van Niekirk L. Deficiencies of MRI in the diagnosis of chronic symptomatic lateral ankle ligament injuries. \textit{Foot Ankle Surg.} 2007;13:171-176.
14. Labovitz JM, Schweitzer ME. Occult osseous injuries after ankle sprains: incidence, location, pattern and age. \textit{Foot Ankle Int.} 1998; 19:661-667.
15. Lazzarini KM, Troiano RN, Smith RC. Can running cause the appearance of marrow edema on MR images of the foot and ankle? \textit{Radiology.} 1997;202:540-542.
16. Nakame A, Engebretsen L, Bahr R, Kroshaug T, Ochi M. Natural history of bone bruises after acute knee injury: clinical outcome and histopathological findings. \textit{Knee Surg Sports Traumatol Arthosc.} 2006;14:1252-1258.
17. Nishimura G, Yamato M, Togawa M. Trabecular trauma of the talus and medial malleolar concurrent with lateral collateral ligamentous injuries of the ankle: evaluation with MR imaging. \textit{Skeletal Radiol.} 1996;25:49-54.
18. Park HJ, Cha SD, Kim SS, et al. Accuracy of MRI findings in chronic lateral ankle ligament injury: comparison with surgical findings. \textit{Clin Radiol.} 2012;67:313-318.
19. Pinar H, Akseki D, Kovankilikaya I, Arac S, Bozkurt M. Bone bruises detected by magnetic resonance imaging following lateral ankle sprains. \textit{Knee Surg Sports Traumatol Arthosc.} 1997;5:113-117.
20. Rijke AM, Goitz HT, McCue FC 3rd, Dee PM. Magnetic resonance imaging of injury to the lateral ankle ligaments. \textit{Am J Sports Med.} 1993:21:528-534.
21. Sijbrandij ES, van Gils AP, Louwerens JW, de Lange EE. Posttraumatic subchondral bone contusions and fractures of the talotibial joint: occurrence of ‘kissing’ lesions. \textit{AJR Am J Roentgenol.} 2000;175:1701-1710.
22. Sujitkumar P, Hadfield JM, Yates DW. Sprain or fracture? An analysis of 2000 ankle injuries. Arch Emerg Med. 1986;3:101-106.

23. Verhagen EA, van Tulder M, van der Beek AJ, Bouter LM, van Mechelen W. An economic evaluation of a proprioceptive balance board training programme for the prevention of ankle sprains in volleyball. Br J Sports Med. 2005;39:111-115.

24. Waterman BR, Owens BD, Zacchilli MA, Belmont PJ Jr. The epidemiology of ankle sprains in the United States. J Bone Joint Surg Am. 2010;92:2279-2284.

25. Wei F, Post JM, Braman JE, Meyer EG, Powell JW, Haut RC. Eversion during external rotation of the human cadaver foot produces high ankle sprains. J Orthop Res. 2012;30:1423-1429.

26. Yammine K, Fathi Y. Ankle “sprains” during sport activities with normal radiographs: incidence of associated bone and tendon injuries on MRI findings and its clinical impact. Foot (Edinb). 2011;21:176-178.

27. Zanetti M, De Simoni C, Wetz HH, Zollinger H, Hodler J. Magnetic resonance imaging of injuries to the ankle joint: can it predict clinical outcome? Skeletal Radiol. 1997;26:82-88.