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FULL PAPER

Predicting poor outcome from simple ankle injuries: a prospective cohort study

^{1,2}STUART A BULLOCK, BSc (Hons), MA, ^{1,3}GEORGINA M ALLEN, BM DCH, MRCP, MRCGP, FRCR, DipESSR, MScSEM, ¹MARION S WATSON, MSc, DCR(R) and ^{1,4}DAVID J WILSON, MBBS, BSc, FRCP, FRCR

¹St Luke's Radiology, Oxford, UK

²Warwick Medical School, University of Warwick, Coventry, UK

³Green Templeton College, University of Oxford, Oxford, UK

⁴Medical Sciences Division, University of Oxford, Oxford, UK

Address correspondence to: Mr Stuart A Bullock
E-mail: stu_bullock@hotmail.com

Background: Sprained ankles are common and when there are no signs or evidence of a fracture, conventional management is conservative. At present, there are no clinical markers to identify those that may develop persisting instability and disability that would require rehabilitation or surgery.

Objectives: To investigate the nature and extent of soft tissue ankle injuries, and to consider whether the anatomical severity of injury can predict functional outcome.

Methods: Patients attending a local Accident and Emergency Department in Oxford with an acute ankle injury with no clinical requirement for radiographs, or where radiographs were normal, were invited into the study. Within 5 days, patients underwent a diagnostic ultrasound examination, a cone beam CT study and a disability assessment. Ultrasound and

physiotherapy assessments were repeated at 3 and 6 months.

Results: 100 patients were recruited and grouped based upon injuries. 58 had simple ankle injuries, 21 complex, 19 had significant fractures and 2 were excluded from further follow up analysis. There were no clinically significant differences in pain, disability or functional outcomes between the groups at all points of the study.

Conclusion: Medium to long term clinical outcomes were not solely determined by the severity of injury. Some patients with simple injuries were seen to have ongoing problems, whereas some with complex injuries recovered completely in a shorter period.

Advances in knowledge: The severity of an ankle injury determined by radiological imaging does not necessarily dictate the severity of a patient's symptoms and the trajectory of their recovery.

INTRODUCTION

Ankle injuries are one of the most common presentations to emergency departments, with an estimated incidence of 302,000 new cases per year in the UK¹ accounting for approximately 30% of all sports injuries.² The outcome of these patients is often unknown and although many go on to a full recovery, up to 30% can develop longer term dysfunction and disability.²⁻⁴

The initial management of ankle injuries varies by department and clinician, which is often dictated by the severity and presentation of the patient.^{1,5} Most commonly, the investigation of choice in the emergency department is plain radiographs using the Ottawa Foot and Ankle Rules to determine suitability.⁶ When an injury appears severe or abnormalities are noted on radiographs, the patient is routinely referred to fracture clinic for further assessment and management. However, the clear majority of patients

with ankle injuries are provided with PRICE (Protection, Rest, Ice, Compression, Elevation) advice in the emergency department to then self-manage their recovery at home,⁵ with a tubular compression bandage being the most common adjunct provided to patients.¹

This management may be sufficient for many, yet there are some patients who go on to develop more chronic problems or have a delayed recovery.^{2,3} These patients require further primary care consultations and often referrals to allied health professionals. Injuries that become chronic are often assumed to have been more severe initially. Yet, there are at present no clinical indicators or markers to identify those that are more likely to develop persisting dysfunction and disability that would require rehabilitation or surgery.

This study aimed to investigate the functional outcome of patients during the recovery period following an ankle

injury, and to determine whether these were linked to the severity of injury sustained, as determined radiologically. The hypothesis was that functional recovery following an ankle soft tissue injury is not primarily determined by the anatomical severity of injury, and that there is no significant difference in recovery when solely based upon radiological diagnosis.

METHODS AND MATERIALS

Participants

A prospective observational cohort study was conducted between February 2013 and August 2015 of 100 patients recruited from the John Radcliffe Hospital Accident and Emergency (A&E) Department in Oxford. Patients were included in the study if they were ≥ 18 years of age, English speaking and not pregnant, with a soft tissue injury of the ankle not requiring radiographs, or where radiographs were deemed normal. Following advice from the treating clinician in the emergency department, patients were invited to take part in the study and provided with information to contact the study coordinators.

The study was registered and approved by the UK Medical Research and Ethics Committee (12/SC/0596).

Imaging and examinations

The Ottawa Foot and Ankle Rules, routinely used by clinicians in emergency departments, were used at the local acute hospital to determine whether X-ray examination of the ankle was necessary. The initial examination of this study took place within 5 days of injury, and all patients underwent a low-dose cone beam CT, an ultrasound examination scan and a disability assessment. If abnormalities were identified that warranted further investigations or advice the patients were referred back to A&E or to the Trauma and Orthopaedics service at the John Radcliffe Hospital. The CT was performed by one senior radiographer with 34 years' experience on a Verity (Planmed) extremity CT scanner (Planmed, Helsinki, Finland) with the patient sitting. The ultrasound examination was performed by one of two musculoskeletal radiologists with 35 and 22 years' experience of ultrasound on a GE Logiq E9 machine (General Electric, Boston, MA) using a 5 to 15 MHz linear array probe and a 5 to 15 MHz hockey stick probe with fusion technology. The examination included the joints, ligaments, tendons, muscles, bones and other soft tissues. The findings were recorded before review of the CT and then repeated if necessary.

The results of the initial imaging investigations allowed for the division of patients into analysis groups for follow up. Patients who were found to have significant fractures, anything beyond

small avulsion fractures without loss of the parent bone stability, were considered as the "fracture" group. Simple avulsions are extremely common in ligament injuries and are not treated by orthopaedic surgeons as fractures. Therefore, for the purposes of this study, they were regarded as an extension of a ligament tear. Classification of patients into "simple" or "complex" soft tissue injury groups was determined using the criteria laid out in Table 1. A sprain was regarded as oedema within a ligament and possibly neovascularity but without any evidence of fibre disruption. A partial tear included these signs with the addition of disruption to some of the fibres, and a full tear was defined as separation of all the fibres.

All patients were invited to follow up, conducted at 3 and 6 months after injury. Ultrasound examination was repeated by a consultant musculoskeletal radiologist and a physical examination was performed by a musculoskeletal physiotherapist. At each assessment, a visual analogue scale (VAS) pain score of 0 to 10 and EQ-5D-5L⁷ quality of life (QoL) questionnaire was completed.

Functional assessment

Physical examinations were performed in long sitting on an examination bed and included observation of the presence of swelling, range of motion (ROM), pain on active movement, strength, pain with resisted movement and laxity by means of the anterior draw test and the talar tilt test. Additionally, several dynamic measurements were performed in standing which included hopping, heel raises, proprioception and weight-bearing dorsiflexion (WB DF). To assess proprioception patients were asked to stand on one leg with arms crossed in front and time was counted, using a stopwatch, until they became unbalanced. If the patient could complete this for 30 s, then the test was repeated but with the eyes closed. For hopping, patients were asked to hop for as long as possible on one leg without any support and the number completed was counted. Heel raises were performed by standing on one leg with balance support only and raising up onto the toes as many times as possible and again the number completed was counted. It was also recorded whether there was pain or not when hopping and completing heel raises. WB DF was assessed by asking the patient to keep the foot flat to the floor and bringing the knee forwards over the toes. The distance between a straight line to the floor from the most anterior part of the patella to the toes was measured. All components of the examinations were marked as normal or abnormal using the contralateral side to the injury as a baseline, as is routinely performed in clinical practice. Statistical analyses were performed using SPSS (v. 23, IBM, Armonk, NY).

Table 1. Classification of soft tissue injury

Simple ligament injury	Complex ligament injury
Tears of Anterior talofibular ligament, Anterior tibiofibular ligament (without diastasis), Talonavicular ligament or, Sprains of other ligaments.	Tears of three or more simple ligaments, or one or more of Calcaneofibular ligament, Deltoid complex, Spring ligament, Anterior tibiofibular ligament (with diastasis).

Table 2. Demographics by subgroup

	Sex (M:F)	Age (mean)	Age (range)
Whole cohort	53:47	33	18–68
Simple	30:28	30	18–63
Complex	13:8	35	18–68
Fracture	9:10	38	20–62

RESULTS

Attendance

All 100 recruited patients attended the initial examination, with a cohort mean age of 33 years. Age and sex demographics were similar across the subgroups when compared to the whole cohort (Table 2). Although we offered examination by CT and ultrasound to all patients, all of those who consented to participate had undergone a radiographic examination, with a normal result. Following the initial examinations 2 patients were excluded and the remaining 98 were invited for follow ups. The number of ankle injuries included in the study totalled 101, as 1 patient injured both ankles. Loss to follow up was 59% at both 3 and 6 months for the simple injury group, 57% at 3 months and 62% at 6 months for the complex injury group, and 37% at 3 months and 63% at 6 months in the fracture group (Figure 1).

Injuries

The most common soft tissue injury found on ultrasound examination was to the anterior talofibular ligament (ATFL) (Figure 2) at 83% with complete tears in 67% of cases (Table 3). Deltoid complex injuries were the second most common, with

the majority being sprains. The calcaneofibular ligament (CFL) and talonavicular ligaments were also common injuries amongst the cohort. Also of note are 15 complete tears of the anterior inferior tibiofibular ligament, of which none showed diastasis on dynamic imaging. It was very common for people to sustain multiple soft tissue injuries with 27% injuring a single ligament, 33% two, 21% three, 8% four and 4% five. Significant fractures were seen in 19 patients of which 7 were seen on ultrasound examination and all were detected by CT. An in depth analysis of the fractures in the fracture group has been presented elsewhere and as such will not be discussed in detail here.⁸

Outcome measures

Both VAS and QoL scores showed an overall improvement throughout the study (Table 4). There was minimal difference between groups at all stages for mean VAS scores with very similar ranges, apart from the complex group at 3 months which had a slightly higher mean pain score.

For the QoL measure, there was minimal difference between the group means, particularly at the initial assessment

Figure 1. Patient attendance at each stage of the study within analysis groups.

Figure 2. Ultrasound imaging of anterior talofibular ligament tears.

and at the 6-month point. There was a slight difference at 3 months with much wider ranges in the complex and fracture groups, however, none of these differences were statistically significant.

20 follow-ups occurred more than 45 days outside of the expected follow-up date, so the data from these has not been included in the statistics comparing 3- and 6-month outcomes. However, all VAS and QoL scores have been plotted against time ([Figure 3](#)) to highlight that there was a similar recovery trajectory between the groups.

Physiotherapy assessments

Proprioception was markedly reduced in all groups at 3 months and in the simple and complex soft tissue groups at 6 months

([Table 5](#)). Although seemingly improving in the complex and fracture groups, it stayed much the same in the simple.

Swelling was prevalent, particularly so in the complex group at 3 months. All groups showed an improvement, but it was still evident at similar levels across the groups at 6 months. ROM loss was also a common finding at 3 months in all groups, which can also be seen by the prevalence of a reduction in WB DF.

Dynamically, hopping weakness was a common finding at 3 months which was often accompanied by pain. By 6 months, although it was more likely to be painless hopping weakness that was observed. Laxity was also prevalent in the groups at all stages of follow up, although in the simple group appearing to be less so at 3 months compared to 6. Apart from swelling and laxity at

Table 3. Incidence of injury to soft tissues

ATFL	83	Deltoid complex	39
Complete tear	67	Complete tear	3
Partial tear	9	Partial tear	12
Sprain	7	Sprain	24
CFL	26	TN ligament/joint	21
Complete tear	8	Complete tear	9
Partial tear	8	Partial tear	2
Sprain	10	Sprain	10
ATiF ligament	19	Spring ligament	14
Complete tear	15	Complete tear	3
Sprain	4	Partial tear	3
CC ligament	3	Sprain	8
Complete tear	3		

ATFL, anterior talofibular ligament; ATiF, anterior tibiofibular; CC, calcaneocuboid; CFL, calcaneofibular ligament; TN, talonavicular.

3 months, there was no statistically significant differences in any of the other outcomes at any points.

DISCUSSION

This study has shown that the overall outcome of patients within this cohort was not primarily determined by the anatomical categorization of injury. It has, however, observed many points worthy of discussion.

Injuries

It is well-documented that the majority of ankle injuries are to the lateral structures,^{9–12} owing to the most common mechanism of injury; combined inversion, plantarflexion and internal rotation.¹² Renström and Lynch¹¹ found that 75% of ankle injuries were to the lateral ligaments and Hubbard and Hicks-Little describe finding that 66% were to the ATFL alone and a further 20% in combination with the CFL.⁹ A similar occurrence was seen within our cohort with the ATFL injured in 83% of cases

and the CFL in 26%. What was also observed was the frequency of concurrent injury to other soft tissue structures. Second to the ATFL was injury to the deltoid complex of which only 6 of the 39 patients had not also injured the ATFL. From this, it could be hypothesized that in attempting to recover from an inversion or eversion injury the ankle commonly overcompensates in returning to neutral, damaging structures on the opposite side. Also, injury to the talonavicular ligament was surprisingly common and this has been the topic of a publication with an analysis of the ligaments biomechanical function.¹³

Imaging

The Ottawa Foot and Ankle Rules were designed to assist clinical decision-making and avoid unnecessary radiography.⁶ It has previously been described in a systematic review that the tool has a sensitivity of almost 100% but quite variable specificity.¹⁴ In this study, 19 patients had substantial fractures that were undetected by assessment in the emergency department using these rules alongside X-rays. All 19 were noted on CT examination of which 7 were also seen on ultrasound examination.

CT examination does increase the detectability of fractures that may otherwise be missed, however, it is clear that performing a CT scan on every ankle injury is not necessarily a feasible option. Whereas ultrasound examination could have a role to play and has been suggested as a triage tool, rather than the Ottawa rules, to detect fractures and determine soft tissue injuries.¹⁵ This could reduce the number of radiographs requested and, therefore, reduce patients exposure to radiation. However, there are limitations to using ultrasound examination and accurate diagnosis depends on experienced clinicians. An in-depth analysis of the substantial fractures found on examination and a detail comparison of imaging modalities has been discussed in a presentation of this study⁸ and is the subject of a future publication.

Outcome measures

A similar recovery trajectory was seen in all analysis groups for pain and QoL outcomes, with very similar intergroup mean scores. The VAS score only showed a slightly higher mean

Table 4. Outcome measure scores at baseline, 3 and 6 months

	0 months mean (SD) (IQR)	3 months mean (SD) (IQR)	6 months mean (SD) (IQR)
EQ-5D-5L			
Simple	0.50 (0.20) (0.36 to 0.65)	0.82 (0.11) (0.74 to 0.84)	0.86 (0.11) (0.79 to 1.0)
Complex	0.53 (0.20) (0.44 to 0.69)	0.70 (0.22) (0.51 to 0.83)	0.81 (0.10) (0.72 to 0.89)
Fracture	0.43 (0.25) (0.24 to 0.63)	0.71 (0.18) (0.65 to 0.83)	0.86 (0.15) (0.74 to 1.0)
VAS			
Simple	6.4 (1.8) (5.0 to 8.0)	1.8 (2.0) (0.5 to 2.0)	1.0 (1.1) (0.0 to 2.0)
Complex	6.8 (2.6) (6.0 to 8.8)	2.9 (2.7) (0.0 to 6.0)	1.4 (1.5) (0.0 to 2.8)
Fracture	6.5 (2.5) (3.0 to 8.0)	1.8 (1.2) (0.3 to 3.0)	1.1 (2.2) (0.0 to 2.0)

IQR, interquartile range; SD, standard deviation; VAS, visual analogue scale.

VAS scored on a range from 0 to 10 (0 = no pain, 10 = extreme pain). EQ-5D-5L scored on a range from -0.594 to 1, where 1 is comparable to perfect health, 0 comparable to death and below 0 worse than death.

Figure 3. EQ-5D-5L and pain scores over time within the three analysis groups. VAS, visual analogue scale.

average in the complex group at 3 months, and slightly better mean QoL score in the simple group at 3 months. This could be attributed to a broader spectrum of injuries within the complex group, with the worst injuries that we saw within that cohort. Yet, by 6 months there was, on average, no real difference based upon an injury classification. On reflection, the choice of outcome measures was appropriate, with the inclusion of the EQ-5D-5L successfully capturing the global effect of the injury on the patient's life.

Physical examination and functional Outcome

An analysis of the physical examination findings identified several interesting points. Swelling at 3 months was statistically more likely to be present in the complex group. This could be attributed to more severe injuries as the simple group had full swelling resolution in more than half of cases by this point.

However, by 6 months there was no real difference between the groups with less than a third of the cohort having any swelling. When comparing the prevalence of swelling alongside ROM measurements across the groups, there was a correlation between having no ROM limitation as swelling resolved. Limited ROM at the ankle can cause functional limitations for patients with day to day tasks and physical activity, which is why regaining full ROM is explained by some as the primary outcome of recovery.^{11,16,17}

As swelling is a major contributing factor to ROM loss, patients are advised to use ice therapy, compression and elevation to limit swelling and control pain.¹⁸ thereby retaining as much function as possible. However, compliance with the recommended management of swelling is questionable. The recommendations for ice use ranges from 10 to 20 min 2–4 times daily, up to 30–45 min every 2 h.¹⁹ Further evidence also presents a confusing

Table 5. Physiotherapy assessments findings at 3- and 6-month follow-ups

	3-month follow-up			6-month follow-up		
	Simple prevalence (95% CI)	Complex prevalence (95% CI)	Fracture prevalence (95% CI)	Simple prevalence (95% CI)	Complex prevalence (95% CI)	Fracture prevalence (95% CI)
Swelling	44 (26, 65) ^a	89 (68, 100) ^a	67 (41, 92)	29 (13, 46)	25 (0, 50)	14 (0, 43)
ROM reduced	39 (22, 61)	67 (33, 100)	42 (17, 67)	17 (4, 33)	25 (0, 63)	14 (0, 43)
Pain with active ROM	26 (9, 44)	57 (22, 89)	50 (25, 75)	8 (0, 21)	13 (0, 38)	14 (0, 43)
Laxity	30 (13, 48) ^b	78 (44, 100) ^b	42 (17, 67)	58 (38, 79)	50 (13, 88)	29 (0, 57)
Strength reduced	0	11 (0, 33)	0	0	0	0
Pain with resistance	0	11 (0, 33)	0	8 (0, 21)	0	0
Hopping weakness	61 (39, 78)	67 (33, 89)	67 (42, 92)	29 (13, 46)	50 (13, 88)	43 (14, 86)
Pain with hopping	30 (13, 48)	67 (33, 89)	50 (17, 83)	17 (4, 33)	25 (0, 63)	14 (0, 43)
WB DF reduced	35 (17, 52)	78 (44, 100)	50 (25, 83)	17 (4, 33)	38 (13, 75)	29 (0, 71)
Proprioception reduced	61 (44, 78)	89 (67, 100)	67 (42, 92)	63 (42, 83)	50 (13, 88)	43 (14, 86)
Heel raises reduced	26 (9, 48)	67 (33, 100)	42 (9, 48)	13 (0, 29)	50 (13, 88)	29 (0, 57)

CI, confidence intervals; ROM, range of motion; WB DF, weight-bearing dorsiflexion.

^a $p < 0.05$ between simple and complex groups for swelling at 3 months.

^b $p < 0.05$ between simple and complex groups for laxity at 3 months.

picture, with a systematic review of cryotherapy highlighting low quality randomized controlled trials, making it difficult to form strong evidence-based recommendations.¹⁹ Although the use of ice was not documented in this study, it was rare to hear patients describe use at the levels recommended in the literature. It could be that poor, early cryotherapy use alongside minimal use of compression, and suboptimal movement and weight-bearing could have led to the increased incidence of swelling and pain, and thus, ROM limitations and functional limitations seen on the EQ-5D-5L.

Another common finding was ligament laxity which is significant as it represents ligamentous failure, often described as mechanical instability.^{9,12} Our study found mechanical instability in over half of all patients at 6 months post-injury, and Hubbard and Hicks-Little⁹ have presented that it can still be prevalent in 30% of patients at 1 year. Having mechanical instability of the ankle does increase the risk of injury recurrence, exacerbated by the combined effects of mechanical and functional instability. Functional instability is caused by neuromuscular deficits, proposed to be secondary to articular mechanoreceptors damage in the injured ligaments alongside deconditioning in the post injury period.¹⁰ This helps to explain the dynamic deficits found in many patients, including reduced proprioception and hopping weakness.

Proprioception was quite markedly reduced in the groups at 3 and 6 months. In many of the patients who reported feeling fine, it was proprioception that was found to be abnormal and a deficit in proprioception has been associated with the occurrence or reoccurrence of soft tissue ankle injuries.²⁰ The same author presents that incorporating proprioceptive exercises into rehabilitation can improve functional outcomes.²⁰

Proprioceptive and neuromuscular training have also been described by Hossain and Thomas³ as the cornerstone of conservative management yet these types of exercises are not routinely given to patients unless they are referred to allied health professionals.

Strength was not something that was notably weak when testing isometrically and through-range in supine, however, dynamically there was definitely weakness across the groups. At 3 months, hopping weakness was often accompanied by pain, reasoning that the discomfort of the action caused an apparent weakness. It was for this reason that heel raises were also assessed and that was commonly reduced, slightly more so in the complex and fracture groups at 3 months. This is an important observation as strength of the ankle is often briefly assessed in non-weight-bearing.^{21,22} But, these findings show that plantarflexion of the ankle into an assessor's hand is not always replicative of the full strength required to perform heel raises and, therefore, many normal functional tasks. Hopping weakness and reduced heel raise strength was still a common finding in half of the complex group at 6 months, possibly suggesting that they had undergone more deconditioning.

Deconditioning following an injury can be attributed to a multitude of factors and the results of this study could suggest that reduced ROM and swelling affected normal physiological use and as such impeded normal function. Although not necessarily felt by the patients, abnormal use may have led to reduced dynamic strength and stability. This emphasizes the importance in the promotion of normal function as soon as possible, with early interventions and continued rehabilitation following an injury.

As previously mentioned the traditional approach to managing soft tissue injuries is to follow PRICE advice, and the evidence described so far has emphasized swelling control and retaining ROM as key elements. Cryotherapy is advised in the initial stages to limit the effect of tissue damage and oedema, and in the subsequent recovery period for pain relief to aid rehabilitation.¹⁸ The most prominent message in current literature, although, is early movement and mobilization encouraging normal function as soon as possible.^{2,5,11,23} This challenges popular lay belief that rest is necessary to protect the injury and allow healing. Bleakley *et al*²³ have gone as far as calling for the R of PRICE to be changed to optimal loading to discourage full rest and encourage mobility. Recently, a randomized controlled trial has even demonstrated that early exercise and mobilization improved ankle function when compared with a group following traditional PRICE principles.⁵ The other key message is that patients should be encouraged to address the common deconditioning and proprioceptive deficits that occur,¹¹ to reduce the functional instability that is often present and thereby, reduce the risk of injury recurrence. Although most of the patients within this study recovered at a similar pace across the groups, the suggestions from current literature could potentially improve the functional outcomes for patients more speedily.

Confounding factors

There are elements that could have affected the patient's recovery that were not considered in this study. Age, mechanism of injury, compliance with PRICE advice, allied health professional treatment, activity levels and rehabilitation performed may have been worthy of further exploration. We did not limit our study to particular activity level groups or sporting activities as we wanted the cohort of patients to be representative of that that would attend an A&E department.

Study limitations

The main weakness of this study was the sample sizes of the analysis groups. It is possible that those that did not attend had fully recovered, but it could also be that patients were seeking medical attention elsewhere and so did not want to continue with the study. Almost all the outcomes had no statistically significant difference across the groups, however, with larger sample sizes there may have been more notable differences. There was similar loss to follow up between the simple and complex soft tissue injury groups throughout the study, which helps to support the analysis that patients recovered on a similar trajectory no matter

the injury. If we had seen a larger loss to follow up in the simple group then it may have been possible to say that that subgroup of patients recovered quicker. The dropout rate in the fracture group was much lower at 3 months, which could be explained by patients seeking reassurance that their fractures had healed. Each examination was conducted by a single clinician, therefore to strengthen the results it might have been beneficial to validate findings through a second assessor. Patients with concurrent or a history of contralateral ankle injury were not excluded from the study. In these cases, clinical judgement was used, as is done in routine clinical practice, on how best to conduct a physical examination; we acknowledge this as a potential weakness in the results.

CONCLUSION

One may have assumed that a more serious injury leads to worse outcomes and a delayed recovery compared to simple injuries. Severity is often based upon anatomical structures and although there were some small differences using this method of categorization, the cohort we observed in this study appeared to recover at a similar rate. This study has also emphasized the importance in the management of swelling and ROM for optimal functional recovery, which patients may not be ideally addressing at present. It also highlighted that many have dynamic deficits that persist placing the patient at a higher risk of injury recurrence. Recovery for the lay person following an ankle injury may require improved advice and education to optimize their return to full function. Overall, this study can conclude that longer-term outcome at 6 months following an ankle injury was not necessarily dictated by the severity of injury as determined by an initial classification based upon radiological findings.

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ETHICS APPROVAL

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