Can American Orthopaedic Foot and Ankle Society (AOFAS) score prevent unnecessary MRI in isolated ankle ligament injuries?

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Abstract

Introduction and Objective: Ankle injuries are the most common musculoskeletal injuries. Its incidence is also high among sports injuries. Direct X-ray, ultrasound and MRI can be requested after the history and physical examination in the patient who presents with ankle ligament injury. Some classifications are used for requesting direct X-ray after ankle injury. Since clear limits are not specified in the literature for MRI, the rate of unnecessary MRI examinations is high. We argue that the decision can be made according to the AOFAS score to be checked before MR is requested, and thus unnecessary MR requests can be reduced.

Material and Method: Ankle MRI images of patients who underwent ankle MRI due to ankle trauma between January 2018 and December 2020 were scanned. 328 patients who met the criteria were included in the study. Patients with AOFAS scores in their outpatient clinic records were identified. AOFAS scores of patients with at least one ligament injury and those with normal MR images were statistically compared. Sensitivity and specificity were determined for the AOFAS score using ROC analysis.

Results: Patients with ligament damage as a result of MRI examination were 21.3% (n=70), and patients without any ligament damage were 78.7% (n=258). There was a statistically significant difference in terms of AOFAS between the group with ligament damage and the group without ligament damage (p<0.05). In the ROC analysis, the AOFAS threshold value for MR request was determined as 80.5 (84.3% sensitivity and 72.3% specificity). Based on the determined threshold value, 73 patients who had unnecessary MRI would have been eliminated, thus reducing the number of MRIs by 42.6%.

Conclusion: The AOFAS scores of patients with ligament damage were statistically significantly lower than those of patients without ligament pathology. Unnecessary MRI can be significantly prevented by using the AOFAS score in ankle traumas without bone fractures.

Keywords

ankle injuries, ankle MRI, AOFAS score, syndesmos
Instability", may develop 2,3. Chronic ankle instability, which develops after acute ankle injuries, is difficult to define. In a meta-analysis conducted by Delahunty et al. 4, it was emphasized that there was no consensus in the literature regarding ankle instability. It was stated that following acute ankle injuries, residual symptoms may remain even after 6–18 months in 72.6% of the patients 5. Tropp et al. defined functional instability as a feeling of insecurity and recurrent sprains, while mechanical instability was defined as the presence of joint motion exceeding the normal ankle range of motion6. While functional instability is due to deficiencies in proprioception and neuromuscular control, mechanical instability may be due to specific deficiencies such as pathological laxity, arthokinematic changes, synovial irritation or degenerative changes2.

Lateral ligament injuries of the ankle are called "low ankle sprains". After obtaining the patient's medical history and performing a physical examination, direct radiography can be performed to detect fractures. In patients with persistent complaints, MRI and surgical procedures may be required if there is a grade 3 ligament sprain8. Syndesmotic ligament injuries, classified as high ankle sprains, are being diagnosed increasingly. High ankle sprains in athletes may lead to significant loss of time. They are associated with long term ankle dysfunctions9. In a study conducted by Waterman et al.10 among all ankle injuries, the rate of patients with syndesmotic ligament injuries was found to be 6.7%.

Ankle decision rules are developed to expedite patient care and reduce the number of ankle and foot radiographs by predicting fractures in foot and ankle traumas 11. In the cases of accompanying bone fractures after ankle trauma, the diagnosis can be made by direct radiography. In patients with isolated ligament injuries, stress radiography may be performed to help with the diagnosis. The frequency of ultrasound use is increasing in ankle ligament injuries. Ultrasound is an easily accessible, inexpensive and reproducible imaging method. With the widespread use of portable ultrasound devices, their use among orthopedic surgeons is increasing. It has higher diagnostic value especially in ATFL and AITFL injury 12. In the study of Ergün et al.13, it was emphasized that the ligament damage can be detected by ultrasound in patients with ankle injury in the first 48 h, and ultrasonography may have an additional role as a triaging tool, to fast-track MRI.

In our study, the MRI results of patients presenting with ankle trauma were scanned. The AOFAS scores of patients with ligament injuries and those who did not have any ligament injuries were compared and it was examined whether they may be a guide when requesting an MRI. When the literature was examined, it was observed that there was not enough information on this subject and studies continue. There are various publications about unnecessary MRI requests in our country. In the study of Kilin et al., the rate of unnecessary CT or MRI was found to be 35%.14. In our study, we investigated whether unnecessary MRI requests might be prevented by using the AOFAS scores in patients with isolated ankle ligament injuries.

Materials and methods

Patients over the age of 18 who underwent ankle MRI in our hospital between January 2018 and December 2020 were scanned. The following inclusion criteria were used in our study. 1. Subjects age 18 and above; 2. History of isolated ankle trauma followed by persistent ankle symptoms; 3. Had MRI of the ipsilateral ankle performed in our Hospital between January 2018 and December 2020; 4. AOFAS scores prior to the MRI, available either in the medical record or retrospectively. Patients with a history of tumor, bone fracture, osteomyelitis, foot and ankle surgery, and patients under the age of 18 were excluded from the study. 328 patients who met the inclusion criteria were included in the study. The MRI scans of the patients were performed in accordance with the ankle MRI protocols applied in our hospital (with an slice thickness of 3 or 6 mm). MRI was performed using Philips, Achieva 3T. After examining the MRI results of the patients, the MRI images of the patients were recorded. They re-evaluated all the films together at the same time and came up with an agreed consensus.

Patients with injuries of the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), posterior talofibular ligament (PTFL) on MRI were classified as the low ankle ligament injury group; patients with injuries of the anterior inferior tibiofibular ligament (AITF), posterior inferior tibiofibular ligament (PITF), inferior transverse ligament (ITL) or interosseous tibiofibular ligament (IOL) were classified as the high ankle ligament injury group; patients with deltoid ligament (DL) injuries were classified as the medial ligament injury group, and those with no pathology in terms of the abovementioned injuries were classified as the normal group.

The medical records of these patients were examined and the scores of those who had preexisting AOFAS scores were compared with the MRI results. The AOFAS score of 101 patients without ligament injury and 70 patients with ligament injury was achieved. In 16 patients with at least one ligament injury and whose AOFAS score could not be reached from the records, the AOFAS score was determined before the MRI by face-to-face interview. Data of 171 patients with AOFAS score were analyzed. The mean AOFAS scores were calculated for each group. It was investigated whether calculating the AOFAS scores before the MRI scan was statistically significant in terms of predicting pathology.
in patients with suspected ligament injuries. ROC analysis was performed on 171 patients with an AOFAS score.

The study was approved by the Ethics Review Committee of our faculty (approval date: 06.05.2021/approval number: 346).

**Statistical analysis**

Statistical analyses were carried out using Statistical Package for Social Sciences (SPSS), version 26 (IBM Corp. Armonk, NY). Descriptive statistics were summarized as numbers, percentages, minimum-maximum values, median, mean and standard deviations. The Chi-square test and Student’s t-test were used. In the analyses, the comparisons in which the probability (p) value was less than 0.05 ($p < 0.05$) were considered statistically significant.

**Results**

MRI scans of the patients were taken an average of 6.41 (SD: 2.04) weeks after injury. When the patients were examined in terms of gender, it was found that 53% were female, 47% were male; and their mean age was found as 39.46 (SD ±14.43) years. There was no significant difference between the ligament injury group (40.60 years) and the normal group (39.16 years) in terms of mean age ($p=0.458$). The mean score of 171 patients whose AOFAS scores were accessed was 80.94 (Table 1).

In the Student’s t-test, a statistically significant difference was found between the AOFAS scores of the patients and the presence of ligament injuries ($p<0.001$).

The number and percentages of patients with ligament injuries are presented in Table 2.

When the patients were examined in terms of injured ligament groups, it was found that 10.3% of the patients had LCL injury, 1.5% had MCL injury, 8.2% had syndesmotic injury, 0.6% had both LCL and MCL injuries, and 0.6% of the patients had damage in all ligaments. The statistical comparison of the AOFAS scores between the groups with injured ligaments and the normal patient group is shown in Table 3.

The AOFAS scores of each group with ligament injuries compared to the normal group were found to be statistically significant ($p<0.05$).

Of the 27 patients who developed isolated ATFL tears, 19 were male and 8 were female. In the Chi-square test, a statistically significant difference was found between the gender of the patients and the ATFL injuries ($p<0.05$) (Figure 1).

It was found that 12 of the 16 patients who developed isolated AITFL tears were male and 4 were female. In the Chi-square test, a statistically significant difference was found between the gender of the patients and the AITFL injuries ($p<0.05$).

When the other ligaments were evaluated in terms of gender, no significant difference was found.

In the ROC analysis (Figure 2), the AOFAS threshold value for MRI requests was determined as 80.5 (84.3% sensitivity and 72.3% specificity). In the ROC analysis, our area under the curve was found to be 0.877.

**Discussion**

Ankle injuries are among the most common traumas of the musculoskeletal system. Today, ankle sprains are diagnosed by requesting imaging tests after obtaining the medical history and performing a physical examination, and the treatments are planned accordingly. Physical examination findings can be summarized as pain and tenderness around the suspected ligament on palpation, edema, and abnormal ankle mobility. However, in acute ankle sprains, it may not always be possible to make an accurate assessment due to pain, especially if a period of 6–8 h has passed since the

#### Table 1. The mean AOFAS scores of the patients according to ligament injuries.

| Injured ligament                     | n   | Minimum | Maximum | Mean±SS     | Student T-test p value |
|--------------------------------------|-----|---------|---------|-------------|------------------------|
| Healthy                              | 101 | 70      | 96      | 84.614±5.3740 | $p<0.001$              |
| Injured                              | 70  | 60      | 88      | 75.643±5.6493 |                        |

#### Table 2. The number and percentages of patients with ligament injuries.

| Injured ligament                     | n   | %   |
|--------------------------------------|-----|-----|
| ATFL                                 | 27  | 8.2 |
| AITFL                                | 16  | 4.9 |
| AITFL + PITFL + ITL + IOL            | 9   | 2.7 |
| DL                                   | 5   | 1.5 |
| ATFL + CFL                           | 3   | 0.9 |
| ATFL + DL                            | 2   | 0.6 |
| PITFL                                | 2   | 0.6 |
| All ligaments                        | 2   | 0.6 |
| ATFL + PTFL                          | 1   | 0.3 |
| ATFL + PTFL + CFL                    | 1   | 0.3 |
| CFL                                  | 1   | 0.3 |
| PTFL                                 | 1   | 0.3 |
| No injuries found                    | 258 | 78.7|
| Total                                | 328 | 100.0 |
incident. For the same reason, the accuracy of stress radiographs is controversial. Some authors argue that it is not always possible to obtain appropriate images due to the fact that it triggers pain in patients, the presence of hematoma and edema that may occur in the joint in the early stage, technical difficulties, and the need for anesthesia. 

The age distribution of the patients in our study was similar to other studies. In the study of Atilla et al., the mean age of patients who presented with ankle trauma was found to be 37. Similarly, in our study, it was found to be 39.46 (18–72). In our study, no significant difference was found between gender and ankle injury (p=0.282). Although 174 female and 154 male patients underwent MRI, it was found that 37 male and 33 female patients had ligament damage. There are studies showing that women suffer from ankle injuries more often than men. In our study, as in the literature, although ankle traumas were more common in women, ligament injuries were found to be more common in men.

Little is known about the cause of this situation. It has been suggested that women are more prone to physical injuries and emotional stress during sports activities; thus they are more prone to ankle injuries than men.

In our study, there were 38 patients with lateral ligament complex injuries. 27 of these were isolated ATFL injuries. According to these results, the most commonly injured ligament of the lateral collateral ligament complex was the ATFL. Our findings were consistent with both the MRI and surgical findings in other studies in the literature.

The mechanism of most ankle injuries is an ankle inversion where the ATFL is anatomically parallel to the direction of the ankle inversion. If it is not correctly diagnosed and the treatment is not appropriately managed, chronic ankle instability, post-traumatic osteoarthritis and anterolateral impingement syndrome may occur in the future. In our study, the mean AOFAS score in patients with injured lateral collateral ligaments was found to be 77.06 (SD: ±5.54). Nery et al. prospectively presented a series of 26 patients who underwent arthroscopic repair for chronic lateral ankle

| The group with injured ligaments | n   | %    | Mean±SS | p   |
|----------------------------------|-----|------|---------|-----|
| LCL                              | 34  | 10.3 | 77.06±5.54 | 0.001 |
| MCL                              | 5   | 1.5  | 73.60±4.16 | 0.002 |
| Syndesmotic                      | 27  | 8.2  | 75.52±4.71 | 0.001 |
| LCL and MCL                      | 2   | 0.6  | 73.00±2.82 | 0.001 |
| LCL + MCL + syndesmotic          | 2   | 0.6  | 61.00±1.41 | 0.005 |
| No injuries found                | 258 | 78.7 | 84.61±5.37*  | —   |
| Total                            | 328 | 100.0 | —       | —   |

*The mean score of 101 patients without any ligament injuries who had preexisting AOFAS scores.
instability. They showed that the postoperative AOFAS scores increased from 58 to 90 within a follow-up period of 27 months. Yeo et al. compared the open modified Broström-Gould method with the arthroscopic method. They reported that in the open group, the AOFAS scores increased from 69 to 89 and in the arthroscopic group, from 67 to 90.

In our study, the reason for the detection of better AOFAS scores in the group with LCL injury might be that the patients who did not need surgery were also detected in the MRI scans.

We detected isolated anterior inferior tibiofibular ligament (AITFL) lesions in 16 of our patients and obtained consistent images. AITFL injuries were present in 27 patients, which were isolated or accompanied by other ligament injuries.

MRI is a non-invasive but relatively expensive imaging method that can provide detailed information about many tissues, especially the soft tissue, greatly facilitates the detection of pathologies, and does not contain ionizing radiation. Schenneck et al. evaluated the results after performing MRI in acute ankle injuries and reported that MRI is a useful diagnostic tool in ankle ligament injuries, especially in patients who can be treated surgically, because it is non-invasive. Similarly, Rijke et al. stated in their study that MRI is a very reliable diagnostic tool in patients with acute, subacute and chronic ankle lateral ligament injuries. Like other studies in the literature, based on our results, we believe that MRI is an adequate diagnostic tool in detecting acute or chronic ligament injuries. In a study conducted by Chandnani et al. with 17 patients with chronic lateral ligament injury, the sensitivity of MRI was found to be 50%, equal to the sensitivity of stress radiographs. However, in their study, only cases with chronic instability were examined. Nevertheless, the authors emphasized that the hemorrhage and edema observed in the acute stage may facilitate the diagnosis with MRI, while these findings disappear in the chronic stage and the diagnosis with MRI becomes more difficult. In chronic cases where there is no increase or decrease in the intra-articular fluid, diagnosis with MRI is difficult. As is known, the ankle joint capsule and ATFL are closely related. Because of this close relationship, the tear in the ligament may not be fully evaluated in MRI examinations, in which it is attempted to scan the joint without swelling due to the pressure created by any fluid (contrast agent, increased intra-articular fluid, bleeding). Whereas the contrast agent that accumulates between the tear ends of the ligament after the injection can make the diagnosis easier.

In various studies, it has been revealed that MRI is performed more often than necessary. In our study, no pathology was detected on 78.7% of the MRI scans. Although the MRI result was negative, a negative result can also be a very useful guide, and sometimes an indispensable one, to further management of the patients. Therefore it would be fair to state the fact that, the maximum potential that MRI might be avoided is 78.7% of cases if a more discriminative investigation were available to screen the cases beforehand. Therefore, it can be said that three out of every four patients underwent MRI unnecessarily. This situation, combined with financial loss, causes delay in the diagnosis of diseases that really require an MRI, and additional effort and time expenditure of healthcare professionals. We think that making the decision whether an MRI is really necessary or it can be postponed based on the AOFAS scores in patients who are considered for ankle MRI due to ankle trauma, may significantly reduce unnecessary MRIs. In the ROC analysis we conducted in our study, the AOFAS threshold value for MRI was determined as 80.5 (84.3% sensitivity and 72.3% specificity). If MRIs had been requested according to the AOFAS scores in our study, MRIs would have been requested for only 87 out of 171 patients with AOFAS scores. In these patients, the number of patients with detected pathologies would have been 59, while the number of normal patients would have been 28. In other words, an unnecessary MRI would have been required for only 1 out of 3 patients. However, no MRI would have been performed in 11 patients with ligament injuries. When the AOFAS score was 80.5, MR would not have been requested although 11 patients had ligament injury. We emphasize that progressive joint damage should be taken into account in these patients. There are publications supporting that ultrasound can be a guide especially for ATFL and AITFL injuries in these patients. With the use of portable ultrasound, orthopedic

Figure 2. The AOFAS score ROC analysis curve of the patients with ligament injuries.
surgeons can provide an easily accessible, inexpensive and reproducible imaging in outpatient clinics. In total, no unnecessary MRI would have been requested for 73 of 171 patients with AOFAS scores. This would have decreased the number of MRIs by 42.6%, significantly reducing the financial loss and the workload of healthcare professionals.

It was emphasized by Sajid et al. that only 4.9% of musculoskeletal MRIs requested by primary care physicians were requested due to appropriate indications, and unnecessary MRIs were requested mostly by patients. In a study conducted in the U.S., it was revealed that in a military hospital, 62% of the MRIs performed following knee injuries were performed unnecessarily, thus causing unnecessary consumption of resources.

However, the reasons for these unnecessary scans can be listed as: the lack of knowledge and experience of physicians, the demand for MRI by patients, the use of MRI due to its advantage of giving fast results about the patient despite the increased workload of the physicians, the practice of defensive medicine of physicians against malpractice accusations, and the fee-for-service system that provides financial benefits to physicians.

It is also an ethical dilemma for physicians that they have to decide for which patients the material resources are more necessary. Due to ineffective planning by healthcare managers and limited resources, physicians are forced to make ethical evaluations in terms of their duty to be beneficial and their obligations within the framework of justice. Performing an MRI in every patient presenting may seem to its advantage of giving fast results about the patient, but in healthcare facilities where the appointments and reporting take long time, this may restrict access to those who are in more urgent need of the medical devices.

Conclusion

In conclusion, we emphasize that MRI is a safe and effective method for detecting ankle ligament pathologies. The AOFAS score is a general and basic score and is easy to apply. We recommend that the AOFAS score be checked for MRI scans in patients with ankle sprain and ongoing complaints. We found that if an AOFAS score of 80.5 and below is used as a criterion for MRI in ankle injuries, unnecessary MRI can be reduced significantly. We argue that time and financial losses can be significantly reduced by avoiding unnecessary MRI scans. Especially in developing economies regions, health budgets are limited. Thus, we argue that MRI devices can help them to be used more effectively in developing economies regions.

Author contributions

Veysel Kandemir Checking the article, literature review, writing the article, Mehmet Sait Akar Data collection, checking the article, literature review, writing the article, Şeyhmus Yiğit, Fatih Durgut, Ramazan Atic, Emin Ozkul, Ramazan Atic Checking the article, literature review. We declare that we prepared the article together.

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