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Correlation Of Clinical Examination, Magnetic Resonance Imaging And Surgical Findings In Diagnosing Ankle Joint Ligament Injuries

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Background: Ankle injury is one of the commonest joints injured, especially in sports, which contribute to significant morbidity and time loss from work. Early and accurate diagnosis is vital to prevent long-term uninviting sequelae. The study aimed to determine the accuracy of clinical findings and magnetic resonance imaging (MRI) concerning surgical findings in patients presenting with chronic ankle pain and/or instability.
Methods: Retrospective review of MRI images and medical reports was performed for all patients who required surgical treatment for chronic ankle instability at two institutions during a four-year period. Medical reports of 22 female and 20 male patients with a mean age of 35.9 years (17–58 years) were analysed. From 42 patients who met the inclusion criteria, only 20 patients underwent surgery. Surgical findings were considered the gold standard. The time interval between MRI scans and arthroscopy/surgery was 5 months (3–10 months).
Results: MRI showed 100% sensitivity for the diagnosis of anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL), and 66.7% sensitivity for the diagnosis of deltoid ligament tears. However, specificity was moderate to low, particularly for deltoid tears. Our study also demonstrated the high accuracy of MRI in detecting chondral injury with 100% sensitivity and specificity. Clinical tests, particularly tenderness on palpation and

anterior drawer test (ADT), provided excellent sensitivity in the diagnosis of ATFL tear but poor specificity.
Conclusion: We concluded that MRI is a reliable instrument in the diagnosis of ATFL, CFL, and chondralinjury at the ankle, but not specific in ruling out the disease. ADT and tenderness on palpation also accuratelydenote ATFL injury with high sensitivity and positive predictive value. The assessment of ligaments on MRI should be performed with caution. Clinical correlation based on the tenderness and ADT is critical when reporting.MRI to avoid over diagnosis, while arthroscopy remains the gold standard.

Keywords – Ankle arthroscopy, MRI ankle, chronic ankle instability

I. INTRODUCTION

Ankle injury is a common musculoskeletal injury and constitutes 10% of emergency department admission [1]. Ankle injury, especially ankle sprain, is mostly seen in sports, which accounts for 10%–30% of sports injuries and the second most prevalent sports injury following knee injury [2,3]. Epidemiological review by Fong et al. (2007) described that the incidence is high in court games and team sports such as soccer, basketball, and volleyball [3].
Adolescents and young adults are relatively more active in sports, which explains the higher prevalence of ankle injury in adults younger than 35 years of age, particularly those between 15–19 years old [3]. Approximately 75% of ankle injuries involve the lateral collateral ligament complex [1,4]. A retrospective review by Crim et al. (2011) described that the most frequent ligament involved in ankle injury was the anterior talofibular ligament (ATFL; 100%), followed by a calcaneofibular ligament (91%), and deltoid ligament (72%). Injury to the posterior talofibular ligament (PTFL) was less common with 49% incidence [5].
The frequency of ankle injury in the population imposes a potential burden to the country in terms of financial and time loss for work and the risk of defeat in a game for professional athletes [1,2].
To date, a few methods are available to diagnose ligament injury to the ankle. The clinical examination may indicate a certain area of the injury to the medial, lateral, or posterior malleolus. It is recommended for a clinical examination to be done after five days post-trauma, as the sensitivity and specificity are higher, i.e., 96% and 84%, respectively [2].
A plain radiograph may be needed to exclude fracture, while an ultrasound is quite helpful in diagnosing ankle injury. However, it requires a highly skilled examiner and a retrospective interpretation by another physician are deemed difficult. Magnetic resonance imaging (MRI) has been used as a standard diagnostic tool, especially in athletes and in chronic ankle pain, for accurate assessment of the ligaments, tendons, occult fractures, and osteochondral injuries. In addition to clinical examination and imaging, arthroscopy offers not only diagnostic but also therapeutic options.

II.MATERIAL AND METHODS

2.1 Methods –

This was a cross-sectional sensitivity and specificity study using secondary data, in which the data were based on the clinical history, radiology, and arthroscopy findings of patients with ankle injuries. Data collection was performed from November 2017 until December 2019. The study population consisted of all patients who attended the orthopaedic outpatient clinic with an ankle injury, from a period of four years (January 2015 until December 2018). The inclusion criteria

were as follows adolescents and adults (aged 15 to 60), male and female, with an ankle injury. MRI ankle had done to the patient. Chronic ankle pain which need arthroscopy/or surgical treatment. The exclusion criteria were concomitant ankle disease such as infection, inflammatory arthritis (osteoarthritis and rheumatoid arthritis), malignancy of the bone, or possible bony metastasis.

A minimum sample size of 16 subjects was required to achieve a power of 80% at a significance level (alpha) of 0.05, to detect a 20% change in the sensitivity of 0.975 [7] using a two-sided binomial test, with the prevalence of 100% [5]. With the anticipation of 20% missing or non-response rate, the sample size required was approximately 19. The sample size was calculated using MS Excel Calculator written by Dr Lin Naing @ Mohd. Ayub Sadiq, 2004.

The data were collected pro forma, which covered all information on the demography, clinical, MRI, and arthroscopy/surgery findings. Two types of MRI machines were used, a Siemens Symphony 1.5 Tesla and a Siemens MagnetomVerio 3.0 Tesla. In this study, the primary data of patients with ankle pain due to injury were collected. Full radiological findings and arthroscopy/surgery reports were taken from the Department of Radiology and the Department of Orthopaedic Outpatient Clinic. The study was assessed and reviewed by the two musculoskeletal radiologists. The study was approved by the ethical committee of the medical faculty.

2.2. Statistic Analysis –

The analysis was performed using IBM SPSS Statistics for Windows (Version 23.0. Armonk, NY: IBM Corp.). Descriptive statistics were utilised for selected variables. The results were presented as frequencies and percentage for Categorical Data (gender, types of ligaments injured, and mode of injury). The normally distributed Numerical Data (age), was presented as mean and standard deviation. Meanwhile, median and interquartile range were used to present the Numerical Data (age), which was not normally distributed. Pearson's chi-square test for independence was used to study the associations between instruments (MRI and arthroscopy) and sociodemographic profiles (age, gender, and sports history), while Fisher's exact test was used if the assumptions of Pearson's chi-square test were not met. All probability values were two-sided, and a level of significance of less than 0.05 (p-value <0.05) was considered statistically significant (Lang &Secic, 2006). Two-by-two contingency tables of ligament injuries vs. no ligament injury diagnoses (yes or no) were used to calculate the sensitivity, specificity, and predictive values.

III. RESULT

The author obtained 42 data of ankle injury patients diagnosed between 2015 until 2018, which fulfilled both inclusion and exclusion criteria. However, among the 42 patients, only 20 patients underwent surgery. The rest were treated conservatively. Some patients have defaulted treatment; thus, no surgery was done for them. In addition, there were missing data in the report findings of ATFL, CFL from arthroscopy, and clinical tests from the surgeons' assessment. The patients with missing data were rejected only when the findings were analysed but included in the analysis of other objectives. Due to the limited number of arthroscopies done over the years, open ankle surgery is considered as the gold standard.

The study group consisted of 42 patients, 52.4% were females (n=22) and 47.6% were males (n= 20). The minimum age of the 42 patients was 17 years old, whereas the maximum age was 58 years old. It is normally distributed with a mean 35.17 and standard deviation of 9.45.

3.1 Mode of injury -

There were 2 missing data for the mechanism of injury from the 42 patients. From the 40 patients, 25 (62.5%) had ankle injury due to sports-related activity, and 15 (37.5%) patients had an injury that was not related to sports activity. Among the types of sports were futsal, football, netball, and badminton. Table 1 shows that futsal ranked as the highest incidence in sports-related injury with 9 (36%) patients, followed by football (n=6, 24%), netball and badminton (both 4 patients, 16%), and rugby (n=2, 8%). Meanwhile, the cause of injury not related to sports comprised of 80% (n=12) patients who tripped and fell, while the rest 20% (n=3) was involved in motor vehicle accidents.

Table– 1.Distribution of different type of sports in patients with chronic ankle instability

Variable	**n**	**%**
Badminton	4	16.0
Futsal	9	36.0
Football	6	24.0
Netball	4	16.0
Rugby	2	8.0
Total	25	100

3.2 Type of ligaments injured -

There were 32 patients (76.2%) recorded with ATFL injury, 32 patients (76.2%) with CFL injury, 22 patients (52.4%) with deltoid injury, and 21 patients with PTFL injury (50%). Among the 42 patients, only 20 patients underwent surgery. Table 2 shows the frequency of ATFL injury detected from surgery as 77.8% (n =14 with 2 missing data), CFL with 63.6% (n=7 with 9 missing data), and deltoid with 4.8% (n= 2 with 18 missing data). No PTFL findings were documented in all surgeries.

Table–2. Distribution of different type of ligaments injury detected by surgery/arthroscopy

Variables	**n**	**%**
ATFL		
Yes	14	77.8
No	4	22.2
CFL		
Yes	7	63.6
No	4	36.4
Deltoid		
Yes	2	4.8
No	0	0

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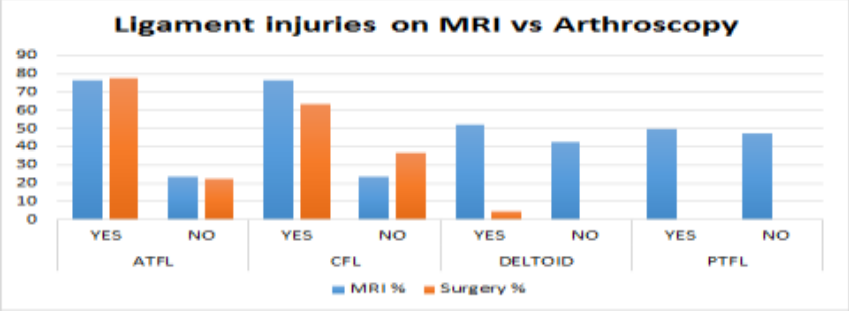

Figure 1: Distribution of different type of ligaments injury detected by MRI vs. surgery

Figure 1 demonstrates that the frequencies of ligament injury types in both MRI and surgical methods; with the most frequent was ATFL, followed by CFL, and deltoid. None of the surgery documented on PTFL.

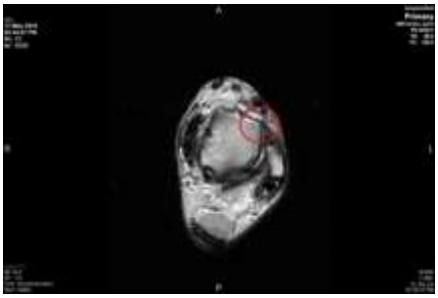

Figure 2. MRI left ankle (axial) T2-weighted image. ATFL appears thickened and heterogenous hyperintense suggestive of a high-grade tear.

Figure 3. MRI left ankle (coronal) PD Fat-Sat sequence. CFL appears lax and wavy (small circle). There is loss of fat striations of deltoid ligament (big circle).

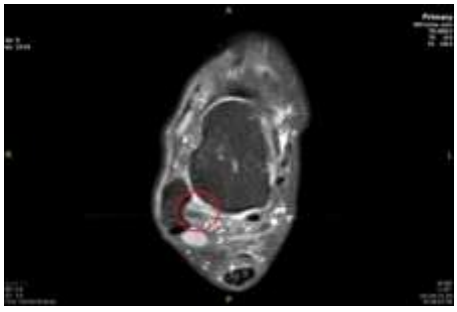

Figure 4. MRI Right Ankle (Axial) PD Fat-Sat sequence. Posterior talofibular ligament (PTFL) has lost its fat striations, appears thickened and has isointense signal intensity in keeping with

chronic tear.

Most patients had lateral ligament injury, which comprised of 90.5% of the patients. Out of these, combined lateral and medial ligament injury occurred in 47.4% of patients while isolated lateral ligament injury occurred in 52.6% of patients. Meanwhile, isolated medial ligament injury only occurred in 9.5% of patients. Table 3 showed that majority of patients had partial ATFL tear (66.7%), followed by complete or no tear (16.7%). There were 2 missing data on ATFL injury from surgery finding.

Table -3. Frequency of complete or partial ATFL tears (surgery)

Variable	**n**	**%**
Complete tear	3	16.7
Partial tear	12	66.7
No tear	3	16.7
Total	18	100

3.3 Study of Association

In association between socio-demographic factors and ATFL injury, three factors were analysed using Chi square (categorical data) and independent T test (numerical data). The factors were age, gender and involvement in sports. Statistically significant p value is taken ≤ 0.05. The results showed that gender is significantly associated with ATFL injury of the ankle with p value of 0.003. Age and sports are not significantly associated with ankle ligament injury. Table 4 and Table 5 summarize the findings.

Table-4. Association between age, gender, and sports on ATFL injury (MRI findings)

Variables	**Yes (n)**	**%**	**No (n)**	**%**	**p-value**
Age”	32	36.6 (8.92)	10	30.5 (10.0)	0.073
Gender*					
Male	11	55.0	9	45.2	0.003
Female	21	95.5	1	4.5	
Sports*					
Yes	21	84.0	4	16.0	0.204
No	10	66.7	5	33.3	

*” Mean (Standard Deviation): independent t-test; *n (%): Pearson chi-square test*

Table- 5. Association between age, gender, and sports on ATFL injury (surgery findings)

Variables	**Yes (n)**	**%**	**No (n)**	**%**	**p-value**
Age”	14	36.1 (6.40)	4	38 (7.48)	0.614
Gender*					
Male	4	57.1	3	42.9	0.245
Female	10	90.9	1	9.1	
Sports*					
Yes	10	76.9	3	23.1	0.888
No	4	80.0	1	20.0	

*" Mean (Standard Deviation): independent t-test; *n(%) : Pearson chi-square test*

3.4 Sensitivity and Specificity

3.4.1MRI Finding vs. Arthroscopy/Surgery

Out of 42 cases, 20 patients underwent surgery. Among these 20 patients who had surgery, their MRI findings were reviewed and compared with surgery findings to obtain sensitivity and specificity value. Out of these patients, 17 patients had ATFL tear (3 no tear) detected on MRI and 14 patients had ATFL tear detected by surgery (4 no tear, 2 missing data). The sensitivity, specificity and accuracy of MRI in diagnosing ATFL tear are 100%, 50%, and 88.9% respectively. For CFL injury, 10 (9 no tear, 1 missing data) patients had CFL tear detected on MRI, but only 7 patients (4 no tear, 9 missing data) had CFL tear detected by surgery. The sensitivity, specificity and accuracy of MRI in diagnosing CFL tear are 100%, 50%, and 80% respectively. For deltoid injury, 13 patients (7 no tear) had ATFL tear detected on MRI, with only 3 patients reported to have deltoid injury on surgery (17 missing data). MRI sensitivity, specificity and accuracy in diagnosing deltoid ligament injury are 66.7%, 0%, and 66.7% respectively. MRI detected chondral injury in 3 patients (17 no injury) and 3 patients detected on surgery (3 no injury, 14 missing data) giving the sensitivity, specificity and accuracy of 100%. Table 6 summarises the findings.

Table-6.The sensitivity and specificity of MRI in detecting different types of injury

Type of injury	**MRI (n)**	**Surgery (n)**	**Sensitivity of MRI (%)**	**Specificity of MRI (%)**	**PPV (%)**	**NPV (%)**	**Accuracy**
ATFL	17	14	100	50	87.5	100	88.9
CFL	10	7	100	50	87.5	100	80.0
Deltoid	13	3	66.7	0	100	0	66.7
Chondral	3	3	100	100	100	100	100

3.4.2 Clinical tests vs. Arthroscopy/Surgery

Among 20 patients who had surgery, 14 patients had ATFL tear (4 no tear, 2 missing data). The clinical findings (anterior drawer test and tenderness on palpation) for these patients were reviewed and compared with surgery finding. Out of these patients, 9 had positive ADT (3 negative ADT, 8 missing data) and all patients (20) had positive tenderness on palpation. The sensitivity, specificity and accuracy of ADT in predicting ATFL tear are 77.8%, 0% and 77.8% respectively. The sensitivity, specificity and accuracy of palpation (tenderness) in predicting ATFL tear are 100%, 0% and 100% respectively. Table 7 summarises the findings.

Table-7. The sensitivity and specificity of different clinical tests in predicting ATFL injury

Clinical Test	**Positive clinical finding (n)**	**Surgery (n)**	**Sensitivity of test (%)**	**Specificity of test (%)**	**PPV (%)**	**NPV (%)**	**Accuracy**
ADT	9	14	77.8	0	77.8	0	77.8
Tenderness	20	14	100	0	100	0	77.8

IV DISCUSSION

4.1 Distribution of different ligament injury

The present study has found that the most frequent ligament involved in chronic ankle instability is ATFL, followed by CFL, deltoid, and PTFL. These findings are consistent in both MRI and surgery. The results of our study are consistent with previous reports [4, 5]. It was reported that ATFL is the weakest ligament and most prone to injury because it has a low value of maximum load (Frank et al., 2013; Hertel, 2002) -8,9. In addition, most ankle injury mechanisms result from an ankle inversion, where ATFL is anatomically located parallel to the direction of ankle inversion [4]. Chun et al. (2015) also reported that most of the ankle injury involved lateral ligament injury, which is consistent with our current study [4].

The deltoid ligament was not documented in most of the surgeries probably due to its location at the medial ankle. Arthroscopy is accessible via several entry points, namely anteromedial, anterolateral, posteromedial, and posterolateral [6]. The most used for diagnostic scope is anteromedial and anterolateral. However, different entry approaches might be used according to the surgeon's preference. In open surgery, dissection to the medial ankle is unnecessary when the suspected injured ligament was only at the lateral ankle.

None of the arthroscopy reports from the present study documented visualisation of PTFL, which is deemed the least detected in surgeries. It being the strongest of all ankle ligaments, thus it is the least possibly injured compared with other ligaments [5, 6]. Furthermore, it is technically challenging to visualise in arthroscopy [7].

4.2 Association between sociodemographic & clinical history with ligament injury

4.2.1 Gender

Our study found that gender is significantly associated with ATFL injury of the ankle. The number of patients who had ligament injuries was greater in females than in males. This is consistent with previous literature, which demonstrated female had a higher possibility of experiencing ankle injury compared to males [10, 11, 12]. Little information is known as to why this happened. It has been postulated that females are more prone to physical injury and emotional stress during sports activity; thus, they are more prone to get ankle injury compared to men [13].

4.2.2 Mechanism of injury

Although we found that a higher number of patients had ankle injury related to sports, it was not statistically significant. This could be due to the focus of the study of those who specifically had ATFL injury, not ankle injury. Even though the association is not statistically significant, we could still show that most of them (62.5%) had ankle injury due to sports-related activity, namely futsal, football, netball, and badminton. The rest of the patients had injuries to the ankle, mostly due to simple ankle sprain, domestic-related injury, occupational hazard, and road accidents.

4.3 Sensitivity and specificity of MRI in detecting ligament and chondral injury at the ankle

We had minimal data on arthroscopy findings although the procedures were done in two institutions. There is a lack of expertise in this area, i.e., only one ankle surgeon is available per institution; thus, affecting the number of cases done per year. In addition, a previous study by Kerkhoffs et al. (2007) reported that surgical treatment offers no extra benefit in the long-term outcome in patients with chronic ankle instability [14]. This could be the reason why surgeons opt for conservative/non-surgical treatment on the majority of their patients. Most of the time, only patient with severe symptoms or injury would be treated surgically, based on the clinical

findings [15].Moreover, only specific ligaments were documented on arthroscopy reports. In addition to the various scope entry approaches as described by Frank et al. (2013), it might also be attributed to the challenging technique of scope or the lack of an instrument. Therefore, many cases were performed as open surgery [8]. For this reason, open surgery findings are taken as part of the gold standard in analysing accuracy, sensitivity, and specificity.

We found that MRI is highly sensitive in detecting injury to ATFL and CFL with sensitivity and PPV of 100% for both. However, its specificity in ruling out injury is only moderate with a value of 50% for both. On the contrary, we have proven that MRI has an excellent NPV of 100%, with high accuracies of 88.9% and 80.0% in diagnosing ATFL and CFL respectively. Thus, MRI is still considered as a reliable tool. We also found that MRI has moderate sensitivity and low specificity in detecting deltoid injury with 66.7% sensitivity, 0% specificity, and 66.7% accuracy. Because injury to the medial ligament (deltoid) is less frequent, they are not routinely observed at arthroscopy/surgery, which explains the inadequacy of data for the calculation of specificity. Overall, we can conclude that MRI is generally accurate in detecting injury to ATFL and CFL but not so in ruling out the disease. This is partly because we had a small sample size. One false-positive result would tremendously affect the statistics. The accuracy of MRI in diagnosing deltoid ligament is only moderate likely due to this as well. It is therefore recommended to increase the sample size in the future, which would likely take a longer time for data collection, given the low number of arthroscopies done per year.

None of the surgery reports had documented PTFL. A study has reported that PTFL is not well visualised on arthroscopy due to its location [7]. For this reason, the author was unable to analyse the sensitivity and specificity of MRI in detecting this ligament due to the lack of documentation in the gold standard (arthroscopy/surgery).

MRI also delivers reliable results in diagnosing chondral injury as evidenced by the high sensitivity (100%), specificity (100%), and 100% accuracy in the present study. This result is comparable to the findings of previous literature that stated sensitivity and specificity for detecting chondral injury on MRI ranged from 71.4% and 95.4% [6, 16]. This also means that MRI could serve as a reliable tool for follow up of chondral lesions post-surgery.

4.4 Sensitivity and specificity of clinical tests in detecting ligament injury at the ankle

Our study is consistent with previous literature like the study by Croy (2013), whereby his team had 66 subjects with a history of a lateral ankle sprain, examined with ADT to determine its diagnostic accuracy [17]. He found that ADT has high sensitivity (0.74) but low specificity (0.38). Our study also found that ADT has high sensitivity and accuracy but low specificity. This indicated that ADT could be beneficial when used with other physical examinations such as palpation, but it should not be relied upon alone in ruling out ATFL injury [17]. The reliability of ADT is also greatly affected by certain individual variations in terms of examination methods in the positioning of the hand, forced implication, scoring method, and perception of movement. Patient factors such as tissue variation and joint congruency may also influence the outcome of ADT [17, 18].

The talar tilt test is another physical test used for an ankle injury. However, this test is rarely used. In our study, it was only being used once by a surgeon in Hospital Serdang, but not in Hospital Putrajaya. Our study showed that the patient who had a positive talar tilt test also had ATFL injury. It has been proven in the literature that this test is not reliable in ruling out the disease but helps rule in the disease [19, 20].

V CONCLUSION

Our study concluded that most of the ankle injury involves lateral ligaments or combined lateral and medial ligaments injury with only a minority having isolated medial ligament injury. The anterior talofibular ligament is the most injured in chronic ankle instability, followed by calcaneofibular ligament, deltoid, and posterior talofibular ligaments. Most of the patients were young adults, and there was a significant predilection in females, as the number of females who undergo surgery was more significant than males. Most of the patients had a history of sports-related activity, albeit statistically not significant.

We also concluded that MRI delivers high sensitivity, accuracy, and excellent correlation with ATFL, CFL, and chondral injury but with moderate specificity (50%). Clinical tests, which include anterior drawer test and palpation, demonstrate high sensitivity and accuracy. It is recommended that MRI interpretation should be made with caution and to be correlated with clinical findings to increase diagnostic accuracy.

VI RECOMMENDATION

There is a delay in time between MRI and surgery in some cases. Thus, injuries found on MRI may not be present at the time of surgery. Clinical findings such as the anterior drawer test and talar tilt test should be appropriately documented in the patients' record. Findings of arthroscopy should also be improved. Ligaments that were visualised and not visualised should be documented one by one as most of the records that we had only reported the ATFL, while the other ligaments were not mentioned at all. It would also be worthwhile to document on the approach for scope, i.e., medial, lateral, anterior, or posterior approach to better understand the findings documented

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