

Evaluation of Accuracy of Clinical Examination and MRI on Diagnosing Anterior Cruciate Ligament and Meniscal Tears in Comparison to Diagnostic Arthroscopy among Patients Attending at Muhimbili Orthopedic Institute

Hellen Machagge^{1*}, Felix Mrita¹, Mohamed Muhamedhussen², Billy Haonga³,
Cuthbert N. Mcharo¹

¹Muhimbili Orthopedic Institute, Dar-es-Salaam, Tanzania

²Muhimbili University of Health and Allied Sciences, Dar-es-Salaam, Tanzania

³Ebrahim Haji Charitable Health Centre, Dar-es-Salaam, Tanzania

Email: *hellenmawole@gmail.com

How to cite this paper: Machagge, H., Mrita, F., Muhamedhussen, M., Haonga, B. and Mcharo, C.N. (2021) Evaluation of Accuracy of Clinical Examination and MRI on Diagnosing Anterior Cruciate Ligament and Meniscal Tears in Comparison to Diagnostic Arthroscopy among Patients Attending at Muhimbili Orthopedic Institute. *Open Journal of Orthopedics*, 11, 353-370.
<https://doi.org/10.4236/ojo.2021.1112034>

Received: October 29, 2021

Accepted: December 4, 2021

Published: December 7, 2021

Copyright © 2021 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Routine use of Magnetic Resonance Imaging (MRI) as screening test after clinical diagnosis for meniscal and/or anterior cruciate ligament (ACL) has a detrimental effect on patients in limited resourced countries. This study was done to compare accuracy of clinical examination and that of (MRI) on diagnosing meniscal and or (ACL) tears. **Methodology:** A cross-sectional-descriptive study was done on 57 knees of patients. Clinical examination, MRI and then diagnostic arthroscopy, as the gold standard, were done to all the cases. Results were recorded; the accuracies of MRI and clinical examination were evaluated and their results were compared. **Results:** Median age of patients was 40 years. Clinical examination had sensitivity of 93.62% and specificity of 40% for diagnosing meniscal tears; and sensitivity of 100%; and specificity of 97.67% for diagnosing ACL tear. MRI had sensitivity of 85.11%, and specificity of 40% for meniscal tear diagnosis and 71% and 100% respectively for ACL tear diagnosis. Diagnostic accuracy was 84.21% for meniscal and 98.24% for ACL tears by clinical examination and by MRI was 77.19% and 92.98% respectively. **Conclusion:** Clinical examination has higher accuracy than MRI on diagnosing both ACL and meniscal tear. Thus patients may be scheduled for diagnostic and interventional arthroscopy if clinical examination reveals me-

niscal and or ACL injuries. MRI use should be reserved when clinical evaluation is inconclusive or cannot be done.

Keywords

MRI, Clinical Examination, Diagnostic Accuracy, ACL, Meniscal

1. Introduction

Menisci and cruciate ligaments are among the frequently injured structures of the knee hence one of commonest causes of knee pain. These structures have various functions including stabilising the joint, acting as axis for knee rotational movement and neutralization of sudden blows or forces to the knee [1] [2]. Anterior cruciate ligament (ACL) and menisci injuries often occur during sports activities and motor traffic crashes. Other risk factors associated with meniscal and ACL tears include obesity, and female sex [3]-[8]. When these structures are injured, there are detrimental effects to the knee cartilage. Numerous studies have shown that tears of the meniscus lead to development and progression of osteoarthritis of the knee, hence early detection and proper management are of paramount importance [9] [10] [11] [12].

Diagnosis of ACL and meniscal tears can be done clinically, as initial assessment, through thorough history taking and physical examination. The tests done include joint line tenderness, the Apleys test, McMurrays test, Lachman and the anterior drawer test, with various sensitivities and specificities [13]-[18]. It is also done radiologically, which is non invasive, using the magnetic resonance imaging (MRI) scan.

A thorough clinical examination, especially using more than one test, has been shown to have accuracy similar to that of MRI by several authors, on diagnosing ACL and meniscal tears [19] [20] [21] [22] [23]. Hence some studies recommend that the MRI should serve as an additional investigation in doubtful, inconclusive or complex knee injuries only [24] [25] [26] [27].

However, there are other researchers who recommend the use of MRI, as a primary screening tool, to compliment clinical examination of the patients in deriving to diagnosis of meniscal and/or ACL tear, prior to performing arthroscopy [28] [29] [30] [31] [32]. Therefore it is routinely used after clinical assessment of patients, a trend that poses potential risk of lowering emphasis that doctors need to put on clinical examinations of such patients [24] [25] [27]. MRI however is scarcely available in developing countries like ours and it is expensive. This may prevent early and timely treatment of many patients. Hence it is crucial to consider the economic load of doing these MRI scans to all our patients. This also may cause delays in providing proper and timely treatments [27] [33] [34]. In our setting, data on its accuracy on diagnosing ACL and meniscal tears as compared to clinical assessment are limited, hence the study was carried out to find this out.

2. Methodology

A descriptive cross sectional study was done in 57 knees of patients with menisci and/or ACL tears. Clinical examination, MRI and then diagnostic arthroscopy were done to all the candidates at Muhimbili Orthopaedic Institute (MOI) between May 2018 to December 2018. MOI is the largest Orthopaedic and trauma referral center in Tanzania. Knee arthroscopic surgeries generally are performed by Arthroscopy and Sports Medicine Fellowship trained Orthopaedic Surgeons, and few other Orthopaedic Specialists. Patients were enrolled from clinics. Convenient sampling technique was used to obtain the sample for the study. Sample size was calculated using the average occurrence through MOI medical records. The pilot study, that was done for patients treated for ACL and meniscal injuries in the past period from January 2017 to June 2017 which revealed prevalence of 3.3%.

Inclusion criteria for the study were consented patients, of 18 and above years; patients with knee symptoms clinically diagnosed to have meniscus tear and or anterior cruciate ligament tear; patients who were also suitable to do MRI and clinically fit for arthroscopic procedure. The exclusion criteria included patients with previous history of surgical interventions of the ipsilateral knee; with ipsilateral other joint conditions such as neoplasm, inflammatory diseases, infections or grade three and above of degenerative changes seen on plain radiography; patients with acute tear or injury preventing proper physical examination; with associated periarticular or intra articular fractures and with contraindication to do MRI like having intracerebral aneurysmal clips, cardiac pacemaker, metallic foreign body or metal implants which are not made of titanium.

Two Arthroscopy and Sports medicine Fellowship trained Orthopaedic Surgeons and the principal investigator were involved. Thorough history taking and physical examinations were done. McMurray test, joint line tenderness and Apley's test were done to assess for meniscal tears. Anterior drawer test and Lachman test were done to assess for presence of ACL tear. The combined results of physical tests were used to draw the conclusion for presence or absence of meniscal and ACL tears respectively. Findings were recorded. Standard plain xrays were then done and evaluated to ensure the inclusion criteria are met.

MRI scanning of all knees was done before doing diagnostic arthroscopy. This MRI scanning process was done in different diagnostic centers. All the images were collected/uploaded and stored in the compact discs and films. These MRI had similar magnetic field intensity. The discs and films were studied and reported by a Consultant Radiologist at MOI. Results were then recorded. These patients were lastly scheduled for diagnostic arthroscopy, where the findings were recorded and used as gold standard for determining accuracy of MRI and accuracy of clinical results. The time intervals between the performance of the MRI scan and the arthroscopy were recorded. All arthroscopic procedures were performed by the Arthroscopy and Sports medicine Fellowship trained Orthopaedic surgeons. These are the same steps that are applied in our routine practices at

the hospital, hence the study represented realistic scenario of how it is carried out when patients attend at the outpatient clinics.

Information about the patients were collected through interviews and filled in the structured questionnaires; physical examination, MRI scanning and arthroscopic findings were also recorded.

At the end of data collection, three groups of patients were established, that is, those with isolated injury of meniscus or ACL; those with both meniscal and ACL injury and those with normal MRI or clinical examination but with knee symptoms and positive results from diagnostic arthroscopy.

Data analysis was done using Stata version 15.1 (StataCorp, College Station, Texas) where the final analyses were performed. Five main parameters for finding validity of these diagnostic methods were calculated using arthroscopic diagnostic results as reference points/gold standard. Sensitivity, Specificity, Negative Predictive value and Positive Predictive Value and overall Accuracy of both MRI and clinical examination were calculated. The comparison of diagnostic accuracy of MRI and clinical examination was done to find out which had higher accuracy on diagnosing meniscal and or ACL tear where Receiver Operating Characteristic (ROC) curve analysis was also used.

Statistical significance of variables was found using Wilcoxon rank-sum (Mann-Whitney) test.

3. Results

3.1. Socio-Demographics

Among patients enrolled in the study, female were the predominant group with 59.65% ($n = 34$) of participants. Overall, the median age was 40 years with inter quartile range (IQR) of 28 - 44 years. Females with knee injuries were predominantly older than male patients with median of 42 years (IQR 37 - 45 years) as compared to 37 years (IQR 24 - 42 years) respectively. This difference was statistically significant ($p < 0.05$). Majority of participants had secondary education. Statistical significance of variables was found using Wilcoxon rank-sum (Mann-Whitney) test.

Table 1 elaborates on the socio demographic features of the participants, explaining on their age, level of education and occupation.

3.2. Mechanisms of Injury

The mechanisms that led to the tears of menisci and ACL were grouped into four categories. Sports and unknown mechanism, as some patients could not recalled exactly how they sustained the injuries, were the leading causes of tears among the patients.

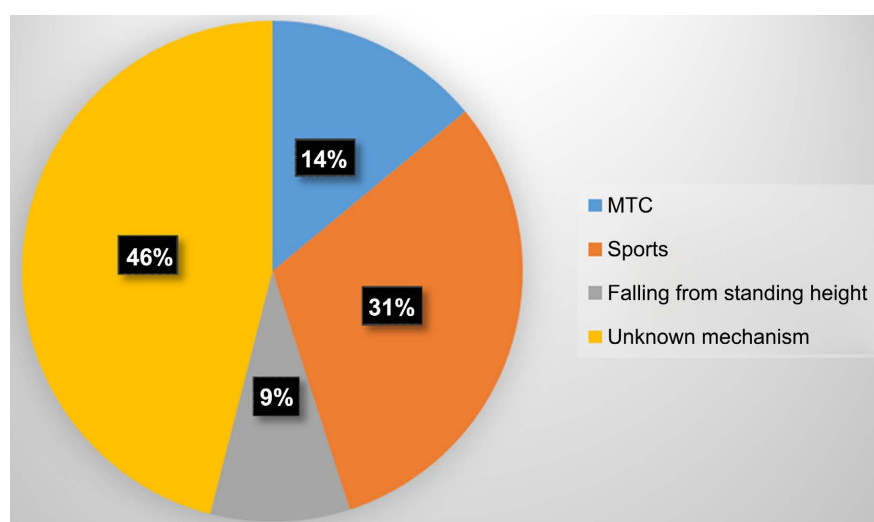
The categories frequencies of mechanism of injury were statistically significant ($p < 0.05$).

Figure 1 showing percentage contributions of injury mechanisms as grouped into four categories.

Table 1. Patients' socio-demographic characteristics.

Characteristics	Female, 34 (59.6)	Male, 23 (40.4)	Total, 57 (100)
Age in years, median (IQR)	42 (37 - 45)	37 (24 - 42)	40 (28 - 44)
Education, n (%)			
Primary	3 (8.82)	7 (30.43)	10 (17.54)
Secondary	20 (58.82)	5 (21.74)	25 (43.86)
Graduate	11 (32.35)	11 (47.83)	22 (38.6)
Occupation, n (%)			
Self-employment	12 (35.26)	2 (8.7)	14 (24.56)
Formal employment	20 (58.82)	20 (86.96)	40 (70.18)
Student	2 (5.88)	1 (4.35)	3 (5.26)

Note: n, number; IQR, Interquartile range.

**Figure 1.** Pie chart showing the proportions of mechanisms of injury.

However, in the unknown mechanism group of patients, 79% associated their knee pain with their daily activities like jogging, running and squatting that they were regularly doing at home. Other patients reported that the pain was felt when they were frequently walking long distances, climbing stairs at their work places (>30 stairs) and standing for long time (approximately above 4 hours) at their work places. All of these patients had isolated meniscal tears and more than 88% were females of whom majority of them appeared obese.

Most of females were observed to delay (>2 yrs) to seek medical help as compared to males counterpart (about 6 months) ($p < 0.05$). Time interval between clinical and MRI diagnosis and doing diagnostic arthroscopy ranged from two to three weeks and none of participants sustained new injury during that time interval.

3.3. Clinical Examinations and MRI Findings

Table 2 shows summary of the clinical examination and MRI findings of the

examined knees. Both MRI and clinical examination found majority of cases to have meniscal tears.

3.4. Arthroscopic Findings

Diagnostic arthroscopy was eventually done to all the cases. There was higher number of females with meniscal tears than males. On the contrary, more males had ACL tears than females. However in both scenarios the differences seen were not statistically significant ($p > 0.12$ and $p > 0.22$ respectively).

Table 3 elaborates results of diagnostic arthroscopy that were used as confirmatory results for the true diagnosis of patients.

Therefore the sensitivities, specificities, negative and positive predictive values of MRI and clinical examination were calculated, with diagnostic arthroscopic as the gold standard. Finally accuracies of both were found and compared.

Table 4 shows Clinical diagnostic results for ACL.

Table 5 summarises the sensitivity, specificity, negative and positive predictive values: and overall accuracy of the clinical examination results.

Table 6 shows MRI results for ACL.

Table 2. Clinical examination and MRI findings.

Clinical findings	Frequency (n)	Percentage (%)
ACL tear	7	12.28
Meniscal tear	42	73.68
Both ACL and meniscal tear	8	14.04
MRI findings		
ACL tear	5	8.77
Meniscal tear	41	71.93
Both ACL and meniscal tear	5	8.77
Normal findings	6	10.53

Table 3. Arthroscopic findings of study participants.

Meniscal tear	Females, n (%)	Males, n (%)	Total, n (%)
Medial	12 (35.29)	10 (43.48)	22 (38.60)
Lateral	7 (20.59)	5 (21.74)	12 (21.05)
Medial and Lateral	8 (23.53)	5 (21.74)	13 (22.81)
Normal	7 (20.59)	3 (13.04)	10 (17.54)
ACL tear			
Negative	32 (94.12)	11 (47.83)	43 (75.44)
Positive	2 (5.88)	12 (52.17)	14 (24.56)
Combined tears			
ACL + meniscal	3 (5.26)	7 (12.28)	10 (17.54)

Table 4. Clinical examination results for ACL.

Clinical dx-ACL	Scope dx-ACL		
	Negative	Positive	Total
Negative	42	0	42
Positive	1	14	15
Total	43	14	57

Sensitivity = 14/14; Specificity = 42/43; Pos. pred. value = 14/15; Neg pred value = 42/42; Accuracy = $14 + 42 / (42 + 14 + 1 + 0)$.

Table 5. Sensitivity, specificity, negative and positive predictive values: and overall accuracy of the clinical examination.

True D defined as crucial ≈ 0		[95% Conf. Inter.]		
Sensitivity	Pr(+ D)	100.00%	100.00%	100.00%
Specificity	Pr(- ~D)	97.67%	93.76%	101.59%
Positive predictive value	Pr(D +)	93.33%	86.86%	99.81%
Negative predictive value	Pr(~D -)	100.00%	100.00%	100.00%
Accuracy		98.24%		

Table 6. MRI results for ACL.

MRI dx-ACL	Scope dx-ACL		
	Negative	Positive	Total
Negative	43	4	47
Positive	0	10	10
Total	43	14	57

Sensitivity = 10/14; Specificity = 43/43; Pos. pred. value = 10/10; Neg pred value = 43/47; Accuracy = $10 + 43 / (43 + 0 + 4 + 10)$.

Table 7 summarises the sensitivity, specificity, negative and positive predictive values: and overall accuracy of the MRI results.

Table 8 shows Clinical diagnostic results for meniscal tear.

Table 9 summarises the sensitivity, specificity, negative and positive predictive values: and overall accuracy of the clinical examination results for meniscal tear.

Table 10 shows MRI results for meniscal tear.

Table 11 summarises the sensitivity, specificity, negative and positive predictive values: and overall accuracy of the MRI meniscal tear results.

3.5. Evaluation of Diagnostic Accuracy of MRI as Compared to That of Clinical Examination

The diagnostic accuracy of MRI and that of clinical examination were also found through ROC (Receiver Operating Characteristic) curve area to best illustrate comparison of diagnostic performances between clinical examination and MRI scan in each segment of concern.

Table 7. Sensitivity, specificity, negative and positive predictive values: and overall accuracy of the MRI.

True D defined as crucial ≈ 0		[95% Conf. Inter.]		
Sensitivity	Pr(+ D)	71.43%	59.70%	83.16%
Specificity	Pr(- ~D)	100.00%	100.00%	100.00%
Positive predictive value	Pr(D +)	100.00%	100.00%	100.00%
Negative predictive value	Pr(~D -)	91.49%	84.25%	98.73%
Accuracy		92.98%		

Table 8. Clinical examination results for meniscal tear.

Scope dx-meniscal			
Clinical dx-meniscal	Negative	Positive	Total
Negative	4	3	7
Positive	6	44	50
Total	10	47	57

Sensitivity = 44/47; Specificity = 4/10; Pos. pred. value = 44/50; Neg pred value = 4/7; Accuracy = 44 + 4/(44 + 4 + 6 + 3).

Table 9. Sensitivity, specificity, negative and positive predictive values and overall accuracy of the clinical examination for meniscal tear.

True D defined as men ≈ 0		[95% Conf. Inter.]		
Sensitivity	Pr(+ D)	93.62%	87.27%	99.96%
Specificity	Pr(- ~D)	40.00%	27.28%	52.72%
Positive predictive value	Pr(D +)	88.00%	79.56%	96.44%
Negative predictive value	Pr(~D -)	57.14%	44.30%	69.99%
Accuracy		84.21%		

Table 10. MRI results for meniscal tear.

Scope dx-meniscal			
MRI dx-meniscal	Negative	Positive	Total
Negative	4	7	11
Positive	6	40	46
Total	10	47	57

Sensitivity = 40/47; Specificity = 4/10; Pos. pred. value = 40/46; Neg pred value = 4/11; Accuracy = 4 + 40/(40 + 4 + 6 + 7).

Figure 2 depicts the diagnostic accuracy of clinical examination as compared to that of MRI on diagnosing meniscal tear.

Accuracy of clinical examination in diagnosing meniscal tears was found to be 84.21%. MRI scan had a diagnostic accuracy of 77.19%, lower as compared to that of clinical examination. However, these results were statistically not significant ($p > 0.09$).

Table 11. Sensitivity, specificity, negative and positive predictive values: and overall accuracy of the MRI meniscal tear results.

True D defined as men ≈ 0		[95% Conf. Inter.]		
Sensitivity	Pr(+ D)	85.11%	75.86%	94.35%
Specificity	Pr(- ~D)	40.00%	27.28%	52.72%
Positive predictive value	Pr(D +)	86.96%	78.21%	95.70%
Negative predictive value	Pr(~D -)	36.36%	23.88%	48.85%
Accuracy		77.19%		

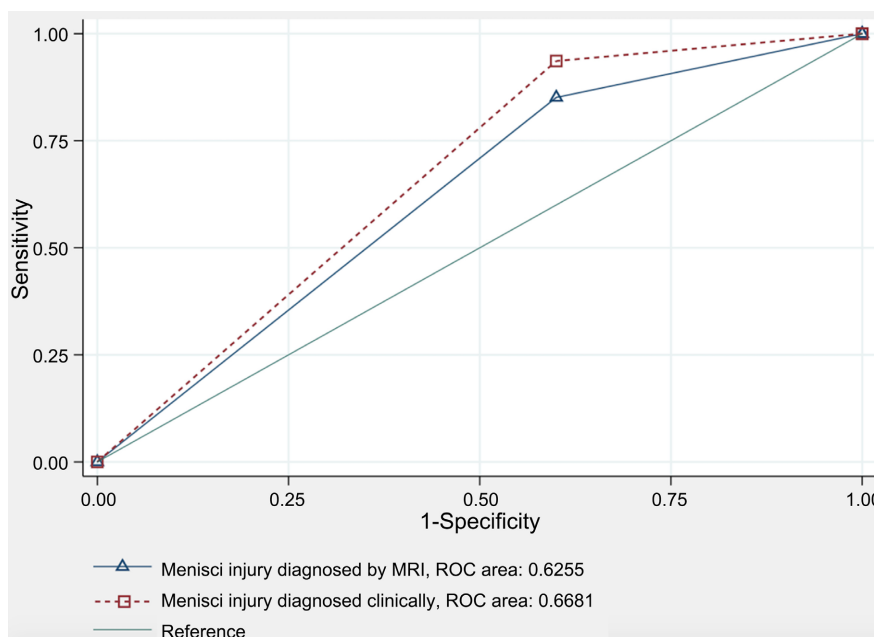


Figure 2. ROC curve describing diagnostic accuracy for diagnosing meniscal tears.

Figure 3 elaborates the comparison on diagnostic accuracy between clinical examination and MRI on diagnosing ACL tear.

Accuracy of diagnosing anterior cruciate ligament tear by clinical examination was 98.24% and that of MRI scan was 92.98%. Therefore, clinical examination had a higher accuracy as compared to MRI scan in diagnosing ACL tears and the difference seen was statistically significant ($p < 0.05$).

4. Discussion

In this study the diagnostic accuracy of physical examination was higher than that of MRI; with $p < 0.05$ for ACL tear and $p > 0.09$ for meniscal tears.

In the study, majority (45%) of patients who did not remember the actual mechanism of their injuries, had meniscal tears. Similar phenomenon was seen in the study done by Cerabona and colleagues where they observed that greater number of their participants could not recall well the mechanism of injury nor they could not correlate their injury mechanisms with specific pattern of meniscal tears they sustained. [35] A study done by Barbara reported that work related

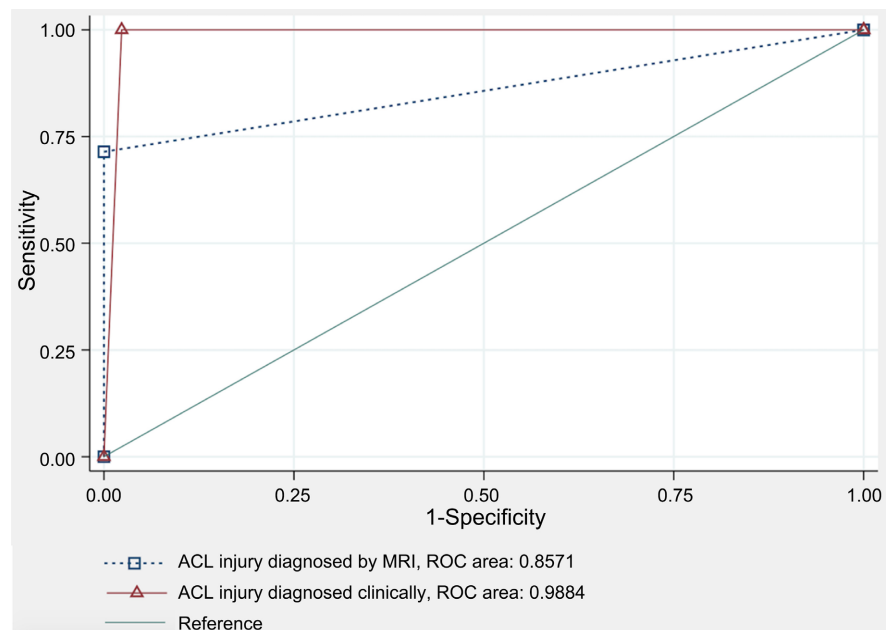


Figure 3. ROC curve describing diagnostic accuracy for diagnosing ACL tear.

walking > 2 miles per day, standing > 2 hrs per day and stair climbing of >30 flights per day had 1.65, 1.63 and 2.28 times risks of sustaining meniscal tears respectively [36]. This positive history of work related walking, stair climbing, routine home based physical exercises and overweight may have a role in the unexplained meniscal tears, as these were also seen as some of risk factors for meniscal tears by researchers [4] [36].

The physical examination was found out to have higher sensitivity as compared to MRI on diagnosing ACL injuries (100% vs 71%). The study done by Gaisgow also revealed that physical examination had 100% sensitivity on diagnosing ACL tear while MRI had 94% [37]. Similarly, Nilton *et al.* showed that physical examination has a higher sensitivity than MRI on diagnosing ACL tear [19].

De Havens, [38] who was comparing physical examination with arthroscopic findings showed that Lachman test alone has an accuracy of 100% when patient is under anesthesia. However, Specificity of MRI in this study was slightly higher than that of clinical examination (100% vs 97.67%). This was also observed in the study done by De Havens and the study by Muthuuri [38] [39].

Decreased sensitivity of MRI may be attributed by difficulties of displaying the ligament fully on sagittal plane due to its anatomical obliquity passage across the joint, as depicted by some studies [40]. MRI results are operator dependent hence the more the skilled and experienced the operator is, the better capability of depicting of the lesion, as elaborated by Geijer [41]. Magnetic Frequency Intensity of the MRI scanner also may affect the accuracy of MRI to pick up the torn ACL, although the effect has been shown by studies to be insignificant [42] [43].

For diagnosing meniscal tears, sensitivity of physical examination was shown

to be slightly higher as compared to the one observed in MRI (93.63 vs 85.11). Rayan *et al.* [44] evaluated 131 patients and found that physical examination had better sensitivity and diagnostic accuracy for meniscal tears than MRI (86% vs 76%). The same finding was seen in a study done by Ercin *et al.* [24] where clinical examination had higher accuracy in diagnosing medial meniscal tears than MRI (93% vs 83%) and marginal higher accuracy for lateral meniscal tears.

However, study done by Leonardo showed that sensitivity of MRI in detecting meniscal injury is higher than that of physical examination (100% vs 85% for medial meniscus and 89% vs 70% for lateral meniscus) [29]. Similar results was also shown in the study by Yan, [45] where MRI had higher sensitivity and accuracy when compared with physical examination in diagnosing meniscal tears.

The differences observed in these studies may be attributed due to differences in skills and experiences of the involved Radiologists in interpreting the images and Medical Personnels who performed the clinical examinations as these have an impact on finding the correct results as elaborated in studies. Differences in MRI scanning protocols in various centres may interfere with accuracy of results. The protocol specifics vary depending on centre's MRI machine software and hardware, radiologist involved, time constraints and patient factors [26] [40].

The study revealed that the overall diagnostic accuracy of physical examination in detecting anterior cruciate ligament and meniscal tears is higher as compared to that of MRI. Similar findings were seen in the study done by Navali *et al.* where he reported that accuracy of physical examination to be 95.8% and that of MRI to be 92.8% [46]. Nilton *et al.* evaluated 120 patients and found that diagnostic accuracy of physical examination was better than that of MRI (90.27% vs 83.33% respectively) [19]. The same results of higher accuracy of clinical examination than of MRI in diagnosing ACL and meniscal tears were reported by Kocabey [26]. Thomas *et al.* found out that the diagnostic accuracy of MRI is lower hence unnecessary MRI scanning increases financial burden and delays treatments to patients [47].

However, Noha *et al.* [48] was evaluating reliability and value of MRI in ACL and meniscal tear diagnosis. He found MRI to have higher overall accuracy in diagnosing them as compared to physical examination.

The differences observed above may be affected by the person carrying out the task. Accuracy of physical examination for meniscal and ACL tears depends on the person performing the physical tests. Usually, when the tests are being performed by experienced or skilled medical personnels, results are better than when tests are performed by inexperienced medical personnels [19] [28]. This may be the reason for higher accurate results in clinical examination. However, in this study, all the MRI results were reported by Consultant Radiologist to minimise bias effect.

Study Limitations

The MRI scan was done in various centers hence some cd reports of different

operating systems could not open at Muhimbili Orthopedic Institute hence led to loss of some participants. However these MRIs were of similar magnetic field intensity.

Convenient sampling technique was applied due to unavoidable circumstances hence this study has shed some light on the subject and calls for bigger randomized studies in the future

Time constraint, that limited the number of participants hence i urgently encourage further study with bigger sample size to better represent the population

5. Conclusion

Physical examination had higher accuracy than MRI (98.24% vs 92.98% for ACL ($p < 0.05$) and 84.21% vs 77.19% for meniscal tears ($p > 0.09$)). When clinical signs and symptoms are well evaluated and results indicate ACL and or meniscal tear, doing an MRI prior to performing diagnostic and interventional arthroscopy is unlikely to be of significance. It is therefore not recommended. Hence MRI use in these diagnoses should be reserved for specific situations like in acute phase of injury where physical examinations cannot be done, in inconclusive physical examination results or in more complex knee injuries. This will foster early and appropriate treatment; and avoid unnecessary costs of MRI to patients.

Recommendations

All Doctors are urged to utilise thoroughly history taking and physical examination skills on patients with knee complaints. This may lower significantly the unnecessary MRI done and allow patients with meniscal or ACL tears early access to appropriate interventions, at lower costs.

Data Availability

Data can be made available on request from the corresponding author.

Funding Statement

This study was self-funded, by the principal author

Acknowledgements

We are grateful to all staff and members of orthopedics and traumatology department at Muhimbili Orthopedic Institute for their support.

Authors' Contribution

H. Machagge worked on literature review, drew up the methodology, collected the data and did analysis after the data was entered. F. Mrita contributed to the methodology and interpretation of data. M. Muhamedhussein assisted on editing the final manuscript. B. Haonga contributed to the accuracy and integrity of all aspects of research and C.N Mcharo supervised the whole research process

and approved the final version.

Conflicts of Interest

No conflicts of interest were entered during the whole process.

References

- [1] Anderson, M.J., Browning, W.M., Urband, C.E., et al. (2016) A Systematic Summary of Systematic Reviews on the Topic of the Anterior Cruciate Ligament. *Orthopaedic Journal of Sports Medicine*, **4**. <https://doi.org/10.1177/2325967116634074>
- [2] Payne, J. and Huins, H. (2017) Knee Ligament Injuries. *Orthopedic and Sports Medicine*, **5**.
- [3] Feucht, M.J., Bigdon, S., Bode, G., Salzmänn, G.M., Dovi-Akue, D., Südkamp, N.P. and Niemeyer, P. (2015) Associated Tears of the Lateral Meniscus in Anterior Cruciate Ligament Injuries: Risk Factors for Different Tear Patterns. *Journal of Orthopaedic Surgery and Research*, **10**, Article No. 34. <https://doi.org/10.1186/s13018-015-0184-x>
- [4] Snoeker, B.A.M., Bakker, E.W.P., Kegel, C.A.T. and Lucas, C. (2013) Risk Factors for Meniscal Tears: A Systematic Review Including Meta-Analysis. *Journal of Orthopedic & Sports Physiotherapy*, **43**, 352-367. <https://doi.org/10.2519/jospt.2013.4295>
- [5] Nuttall, F.Q. (2015) Body Mass Index: Obesity, BMI, and Health: A Critical Review. *Nutrition Today*, **50**, 117-128. <https://doi.org/10.1097/NT.0000000000000092>
- [6] Belanger, L., Burt, D., Callaghan, J., Clifton, S. and Gleberzon, B.J. (2013) Anterior Cruciate Ligament Laxity Related to the Menstrual Cycle: An Updated Systematic Review of the Literature. *The Journal of the Canadian Chiropractic Association*, **57**, 76-86.
- [7] Smith, H.C., Vacek, P., Johnson, R.J., Slauterbeck, J.R., Hashemi, J., Shultz, S. and Beynnon, B.D. (2012) Risk Factors for Anterior Cruciate Ligament Injury: A Review of the Literature-Part 2: Hormonal, Genetic, Cognitive Function, Previous Injury, and Extrinsic Risk Factors. *Sports Health*, **4**, 155-161. <https://doi.org/10.1177/1941738111428282>
- [8] Moses, B. and Orchard, J. (2012) Systematic Review: Annual Incidence of ACL Injury and Surgery in Various Populations. *Research in Sports Medicine*, **20**, 157-179. <https://doi.org/10.1080/15438627.2012.680633>
- [9] Oiestad, B.E., Engebretsen, L., Storheim, K. and Risberg, M.A. (2009) Winner of the 2008 Systematic Review Competition: Knee Osteoarthritis after Anterior Cruciate Ligament Injury. *The American Journal of Sports Medicine*, **37**, 1434-1443. <https://doi.org/10.1177/0363546509338827>
- [10] Magnussen, R.A., Mansour, A.A., Carey, J.L. and Spindler, K.P. (2009) Meniscus Status at Anterior Cruciate Ligament Reconstruction Associated with Radiographic Signs of Osteoarthritis at 5- to 10-Year Follow-Up: A Systematic Review. *Journal of Knee Surgery*, **22**, 347-357. <https://doi.org/10.1055/s-0030-1247773>
- [11] Shelbourne, K.D. and Gray, T. (2000) Results of Anterior Cruciate Ligament Reconstruction Based on Meniscus and Articular Cartilage Status at the Time of Surgery. Five- to Fifteen-Year Evaluations. *The American Journal of Sports Medicine*, **28**, 446-452. <https://doi.org/10.1177/03635465000280040201>
- [12] Chhadia, A.M., Inacio, M.C., Maletis, G.B., Csintalan, R.P., Davis, B.R. and Funahashi T.T. (2011) Are Meniscus and Cartilage Injuries Related to Time to Anterior

- Cruciate Ligament Reconstruction? *The American Journal of Sports Medicine*, **39**, 1894-1899. <https://doi.org/10.1177/0363546511410380>
- [13] Rose, R.E. (2006) The Accuracy of Joint Line Tenderness in the Diagnosis of Meniscal Tears. *West Indian Medical Journal*, **55**, 323-326.
- [14] McMurray, T.P. (1942) The Semilunar Cartilages. *British Journal of Surgery*, **29**, 407-414. <https://doi.org/10.1002/bjs.18002911612>
- [15] Bronstein, R.D. and Schaffer, J.C. (2017) Physical Examination of Knee Ligament Injuries. *Journal of the American Academy of Orthopaedic Surgeons*, **25**, 280-287. <https://doi.org/10.5435/JAAOS-D-15-00463>
- [16] Rinonapoli, G., Carraro, A. and Delcogliano, A. (2011) Clinical Diagnosis of Meniscal Tear Is Not Easy. Reliability of Two Clinical Tests and Magnetic Resonance Imaging. *International Journal of Immunopathology and Pharmacology*, **24**, 39-44. <https://doi.org/10.1177/03946320110241S208>
- [17] Makhmalbaf, H., Moradi, A., Ganji, S. and Omid-Kashani, F. (2013) Accuracy of Lachman and Anterior Drawer Tests for Anterior Cruciate Ligament Injuries. *Archives of Bone and Joint Surgery*, **1**, 94-97
- [18] Malanga, G.A., Andrus, S., Nadler, S.F. and McLean, J. (2003) Physical Examination of the Knee: A Review of the Original Test Description and Scientific Validity of Common Orthopedic Tests. *Archives of Physical Medicine and Rehabilitation*, **84**, 592-603. <https://doi.org/10.1053/apmr.2003.50026>
- [19] Nilton, O.J., George, M., Leão, D.S., Henrique, N. and De Oliveira, C. (2015) Diagnosis of Knee Injuries: Comparison of the Physical Examination and Magnetic Resonance Imaging with the Findings from Arthroscopy. *Revista Brasileira de Ortopedia*, **50**, 712-719. <https://doi.org/10.1016/j.rboe.2015.10.007>
- [20] Swain, M.S., Henschke, N., Kamper, S.J., Downie, A.S., Koes, B.W. and Maher, C.G. (2014) Accuracy of Clinical Tests in the Diagnosis of Anterior Cruciate Ligament Injury: A Systematic Review. *Chiropractic & Manual Therapies*, **22**, Article No. 25. <https://doi.org/10.1186/s12998-014-0025-8>
- [21] Gobbo Rda, R., Rangel Vde, O., Karam, F.C. and Pires, L.A. (2015) Physical Examinations for Diagnosing Meniscal Injuries: Correlation with Surgical Findings. *Revista Brasileira de Ortopedia*, **46**, 726-769. [https://doi.org/10.1016/S2255-4971\(15\)30332-3](https://doi.org/10.1016/S2255-4971(15)30332-3)
- [22] Yogendra, G., Gupta, Y., Mahara, D. and Lamichhane, A. (2016) McMurray's Test and Joint Line Tenderness for Medial Meniscus Tear: Are They Accurate? *Ethiopian Journal of Health Sciences*, **26**, 567-572. <https://doi.org/10.4314/ejhs.v26i6.10>
- [23] Solomon, D.H., Simel, D.L., Bates, D.W., Katz, J.N. and Schaffer, J.L. (2001) Does This Patient Have a Torn Meniscus or Ligament of the Knee? Value of the Physical Examination. *JAMA*, **286**, 1610-1620. <https://doi.org/10.1001/jama.286.13.1610>
- [24] Ercin, E., Kaya, I., Sungur, I., Demirbas, E., Ugras, A.A. and Cetinus, E.M. (2012) History, Clinical Findings, Magnetic Resonance Imaging, and Arthroscopic Correlation in Meniscal Lesions. *Knee Surgery, Sports Traumatology, Arthroscopy*, **20**, 851-856. <https://doi.org/10.1007/s00167-011-1636-4>
- [25] Siddiqui, M.A., Ahmad, I., Sabir, A.B., Ullah, E., Rizvi, S.A. and Rizvi, S.W. (2013) Clinical Examination vs. MRI: Evaluation of Diagnostic Accuracy in Detecting ACL and Meniscal Injuries in Comparison to Arthroscopy. *Polish Orthopedics and Traumatology*, **78**, 59-63.
- [26] Kocabey, J., Tetik, O., Isbell, W.M.J., Atay, O.A. and Johnson, D.L. (2004) The Value of Clinical Examination versus Magnetic Resonance Imaging in the Diagnosis of Meniscal Tears and Anterior Cruciate Ligament Rupture. *Arthroscopy*, **20**, 696-700.

- [https://doi.org/10.1016/S0749-8063\(04\)00593-6](https://doi.org/10.1016/S0749-8063(04)00593-6)
- [27] Mohan, B.R. and Gosal, H. (2007) Reliability of Clinical Diagnosis in Meniscal Tears. *International Orthopaedics*, **31**, 57-60. <https://doi.org/10.1007/s00264-006-0131-x>
 - [28] Rastegar, S., Motifard, M., Nemati, A., Hosseini, N.-S., Tahririan, M.A., Rozati, S.A., Sepiani, M. and Moezi, M. (2016) Where Does Magnetic Resonance Imaging Stand in the Diagnosis of Knee Injuries? *Journal of Research in Medical Sciences*, **21**, 52. <https://doi.org/10.4103/1735-1995.187256>
 - [29] Côrtes Antunes, L., de Souza, J.M.G., Cerqueira, N.B., Dahmera, C., de PinhoTavares, B.A. and de Faria, Â.J.N. (2017) Evaluation of Clinical Tests and Magnetic Resonance Imaging for Knee Meniscal Injuries: Correlation with Video Arthroscopy. *Revista Brasileira de Ortopedia*, **52**, 582-588. <https://doi.org/10.1016/j.rboe.2016.09.009>
 - [30] Yaqoob, J. and Alarm, M.S. (2015) Diagnostic Accuracy of Magnetic Resonance Imaging in Assessment of Meniscal and ACL Tear: Correlation with Arthroscopy. *Pakistan Journal of Medical Sciences*, **31**, 263-268. <https://doi.org/10.12669/pjms.312.6499>
 - [31] Elvenes, J., Jerome, C.P., Reikeras, O. and Johnsen, O. (2000) MRI as a Screening Procedure to Avoid Arthroscopy for Meniscal Tears. *Archives of Orthopaedic and Trauma Surgery*, **120**, 14-16. <https://doi.org/10.1007/PL00021235>
 - [32] Glashow, J.L., Katz, R., Schneider, M. and Scott, W.N. (1989) Double-Blind Assessment of the Value of MRI in the Diagnosis of ACL and Meniscal Lesions. *The Journal of Bone & Joint Surgery*, **71**, 113-119. <https://doi.org/10.2106/00004623-198971010-00017>
 - [33] DAMASK Trial Team (2008) Cost-Effectiveness of Magnetic Resonance Imaging of the Knee for Patients Presenting in Primary Care. *British Journal of General Practice*, **58**, e10-e16. <https://doi.org/10.3399/bjgp08X342660>
 - [34] Suarez-Almazor, M.E., Kaul, P., Kendall, C.J., Saunders, L. and Johnston, D. (1999) The Cost-Effectiveness of Magnetic Resonance Imaging for Patients with Internal Derangement of the Knee. *International Journal of Technology Assessment in Health Care*, **15**, 392-405. <https://doi.org/10.1017/S0266462399152103>
 - [35] Cerabona, F., Sherman, M.F., Bonamo, J. and Sklar, J. (1988) Patterns of Meniscal Injury with Acute Anterior Cruciate Ligament Tears. *The American Journal of Sports Medicine*, **16**, 603-609. <https://doi.org/10.1177/036354658801600609>
 - [36] McDermott, I.D. (2006) Meniscal Tears. *Current Orthopaedics*, **20**, 85-94. <https://doi.org/10.1016/j.cuor.2006.02.010>
 - [37] Gaisgow, S. and Sapega, A. (1994) The Clinical Value and Cost Effectiveness of Magnetic Resonance Imaging (MRI) in the Management of Knee Disorders in a Sports Medicine Practice. *Journal of Orthopaedic Translation*, **18**, 1012.
 - [38] Dehaven, K.E. (1980) Diagnosis of Acute Knee Injuries with Hemarthrosis. *The American Journal of Sports Medicine*, **8**, 9-14. <https://doi.org/10.1177/036354658000800102>
 - [39] Muthuuri, J.M. (2017) A Comparison of Accuracy of Clinical Tests and MRI in the Diagnosis of Meniscal and Anterior Cruciate Ligament Injuries. *East African Orthopaedic Journal*, **11**, 6-11.
 - [40] Li, K., Du, J., Huang, L.-X., Ni, L., Liu, T. and Yang, H.-L. (2017) Diagnostic Accuracy of Magnetic Resonance Imaging for Anterior Cruciate Ligament Injury in Comparison to Arthroscopy: A Meta Analysis. *Scientific Report*, **7**, Article No.7583. <https://doi.org/10.1038/s41598-017-08133-4>

- [41] Geijer, H. and Geijer, M. (2018) Added Value of Double Reading in Diagnostic Radiology: A Systematic Review. *Insights Imaging*, **9**, 287-301. <https://doi.org/10.1007/s13244-018-0599-0>
- [42] Smith, C., McGarvey, C., Harb, Z., Back, D., Houghton, R., Davies, A., *et al.* (2016) Diagnostic Efficacy of 3-T MRI for Knee Injuries Using Arthroscopy as a Reference Standard: A Meta-Analysis. *American Journal of Roentgenology*, **207**, 369-377. <https://doi.org/10.2214/AJR.15.15795>
- [43] Smith, T.O., Lewis, M., Song, F., Toms, A.P., Donell, S.T. and Hing, C.B. (2012) The Diagnostic Accuracy of Anterior Cruciate Ligament Rupture Using Magnetic Resonance Imaging: A Meta-Analysis. *European Journal of Orthopaedic Surgery & Traumatology*, **22**, 315-326. <https://doi.org/10.1007/s00590-011-0829-3>
- [44] Rayan, F., Bhonsle, S. and Shukla, D.D. (2009) Clinical, MRI, and Arthroscopic Correlation in Meniscal and Anterior Cruciate Ligament Injuries. *International Orthopaedics*, **33**, 129-132. <https://doi.org/10.1007/s00264-008-0520-4>
- [45] Yan, R., Wang, H., Yang, Z., Ji, Z.H. and Guo, Y.M. (2011) Predicted Probability of Meniscus Tears: Comparing History and Physical Examination with MRI. *Swiss Medical Weekly*, **141**, Article ID: w13314. <https://doi.org/10.4414/smww.2011.13314>
- [46] Navali, A.M., Bazavar, M., Mohseni, M.A., Safari, B. and Tabrizi, A. (2013) Arthroscopic Evaluation of the Accuracy of Clinical Examination versus MRI in Diagnosing Meniscus Tears and Cruciate Ligament Ruptures. *Archives of Iranian Medicine*, **16**, 229-232.
- [47] Thomas, S., Pullagura, M., Robinson, E., Cohen, A. and Banaszkiewicz, P. (2007) The Value of Magnetic Resonance Imaging in Our Current Management of ACL and Meniscus Injuries. *Knee Surgery, Sports Traumatology, Arthroscopy*, **15**, 533-536. <https://doi.org/10.1007/s00167-006-0259-7>
- [48] Behairy, N.H., Dorgham, M.A. and Khaled, S.A. (2009) Accuracy of Routine Magnetic Resonance Imaging in Meniscal and Ligamentous Injuries of the Knee: Comparison with Arthroscopy. *International Orthopaedics*, **33**, 961-967. <https://doi.org/10.1007/s00264-008-0580-5>

Study Questionnaire

Appendix I: Questionnaire

- 1) Questionnaire No-----
- 2) Hospital Registration Number.....
- 3) Sex:
 - a) Male
 - b) Female
- 4) Age group (years).....
- 5) Highest education level obtained:
 - a) Primary school
 - b) Secondary school/Advanced secondary school
 - c) College/University graduate
- 6) Current occupation:
 - a) Formally Employed
 - b) Self Employed
 - c) Student
- 7) Time duration between doing MRI and arthroscopy (days).....
- 8) Mechanism of injury:
 - a) Motor traffic injury
 - b) Sports Injury
 - c) Fall from height
 - d) Non traumatic/Unknown mechanism of injury
- 9) Knee involved:
 - a) Right side
 - b) Left side
- 10) Duration of injury (days).....
- 11) Clinical findings:
 - a) Joint line tenderness +/-
 - b) McMurray test +/-
 - c) Apley grinding test +/-
 - d) Anterior drawer test +/-
 - e) Lachman test. +/-
- 12) Clinical diagnosis:
 - a) Medial meniscus tear
 - b) Lateral meniscus tear
 - c) Bilateral meniscal tear
 - d) Normal meniscus
 - e) ACL tear
 - f) Intact ACL
- 13) MRI findings:
 - a) Medial meniscus tear
 - b) Lateral meniscus tear
 - c) Bilateral meniscal tear

- d) Normal meniscus
 - e) ACL tear
 - f) Intact ACL
- 14) Arthroscopic findings:
- a) Medial meniscus tear
 - b) Lateral meniscus tear
 - c) Bilateral meniscal tear
 - d) Normal meniscus
 - e) ACL tear
 - f) Intact ACL