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Role of diffusion weighted imaging in assessment of anterior cruciate ligament pathology

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Abstract:

Background: The anterior cruciate ligament (ACL) is a structure that is vital to preserving the knee's normal stability. However, because the ACL is the ligament that sustains injuries the most frequently, it is essential to distinguish between complete and incomplete tears in order to treat patients with incomplete tears without surgery.

To diagnose cruciate ligament tears, knee joint magnetic resonance imaging (MRI) is frequently used. But sometimes it's difficult because edema may hide the ligament fibers. ADC mapping may be useful to confirm whether or not the ligament is continuous for an appropriate diagnosis of incomplete tears because it has been demonstrated that ligament fibers are better visible on diffusion weighted imaging (DWI) and ADC mapping.

Objective: To ascertain how anterior cruciate ligament (ACL) tears are diagnosed and classified as partial or complete using diffusion-weighted (DW) magnetic resonance imaging (MRI) and to compare it with conventional MRI sequences.

Results: For partial tears, 10 cases (50%) were identified using arthroscopy/follow-up, while observer 1 identified 12 cases (60%) and observer 2 identified 9 cases (45%) using DWI/ADC.

For complete tears, 10 cases (50%) were identified using arthroscopy/follow-up, while observer 1 identified 8 cases (40%) and observer 2 identified 11 cases (55%) using DWI/ADC.

Conclusions DWI and ADC are useful tools for diagnosing tears, particularly complete tears, but that caution should be exercised when using these techniques to diagnose partial tears.

Keywords:

Anterior cruciate ligament, Magnetic resonance imaging, Diffusion weighted sequence, Apparent diffusion coefficient.

List of abbreviations:

DWI: Diffusion weighted imaging

ADC: Apparent diffusion coefficient

SPAIR: Spectral attenuated inversion recovery

PD: Proton density

MRI: Magnetic resonance imaging

ACL: Anterior cruciate ligament

PCL: Posterior cruciate ligament

PPV: Positive predictive value

NPV: Negative predictive value

BACKGROUND

The ACL, which is made up of functionally separate anteromedial (AM) and posterolateral (PL) bundles, is one of the key components preserving the knee joint's anteroposterior and rotational stability. [1].

Originating from the anteromedial portion of the intercondylar region of the tibial plateau, this strong band composed of collagenous fibers and connective tissue spreads posteromedially to attach to the lateral femoral condyle. [2].

Magnetic resonance imaging (MRI) is a helpful pre-operative technique in the field of ACL damage that can be used to confirm an ACL disruption and evaluate for any concomitant injuries. [3].

It can be challenging to identify partial ACL tears through physical examination. However,

numerous studies highlight how inadequate the usual MRI techniques in identifying a partial ACL tear. [4].

It has been demonstrated that ligament fibers are more visible on apparent diffusion coefficient (ADC) mapping; hence, ADC mapping may be able to confirm whether or not the ligament is continuous. [5].

A ligament segment appears hypointense on ADC mapping because it contains a lot of collagen and little water. Because ligament fibers would be easier to see on an ADC map, facilitating the determination of the ligament's continuity, this investigation was conducted. [6].

Comparable findings were obtained in the diagnosis and discrimination between total and partial ACL and PCL injuries when the DW sequence was added to traditional MR sequences. [7].

Aim of the work

To compare diffusion-weighted (DW) MRI with standard MRI sequences and ascertain the utility of DW MRI in the diagnosis and distinction of partial and total anterior cruciate ligament (ACL) damage.

METHODS

This was a prospective study approved by Ain Shams university ethics committee conducted on 20 patients after informed consents were obtained, they all were with clinically suspected ACL pathology. Our study lasted from September 2021 to September 2023. Patients were collected by consecutive sampling. The inclusion criteria were patients with clinically suspected ACL pathology, females and males of all age groups. While exclusion criteria were individuals who were ineligible for MR imaging or who had undergone knee surgery or unable to give written consent.

Study tools

Every patient that was a part of the trial underwent the following: thorough clinical examination and proper history taking as regards the onset, duration, character, precipitating factors, as well as associated symptoms, before starting the examination, the patient had the procedure explained to him/her, revision of the patient's clinical history then MRI of the knee was done on a Philips, Achieva 3 Tesla high field MRI unit with a standard extremity coil used. The patient was

positioned supine, the MRI study included some or all of the conventional pulse sequences with added sagittal DWI and ADC mapping with b values (0,400 and 800) and parameters as shown in table 1. The afflicted knee joint was subjected to an MRI evaluation using both conventional and DW/ADC sequences. The ACL was assessed based on the following criteria: (a) If the ACL seen as continuous stretched line of hypointense signal (in conventional and DW/ADC sequences) then considered intact. If not then considered tear; partial or complete as followed (in conventional sequences): If it had a Fuzzy wavy contour, thin but continuous band or interstitial focal or diffuse hyperintense signal then considered partial tear and if there was definite disruption with or without sagging of the fibers then considered complete tear. In DW/ADC sequences, if it displayed thin but continuous hypointense band was considered partial if it showed definite fibers disruption then considered complete tear.

The results for both sequences were evaluated separately by two high experienced radiologists in musculoskeletal imaging and the results were compared with clinical diagnoses, follow up and arthroscopic results when available.

Table 1: MRI protocol parameters

Statistical methods

The Statistical Package for Social Science (IBM Corp., Released 2017) was used to analyze the data that was gathered. Both MedCalc Statistical Software version 18.11.6 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2019) and IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY: IBM Corp.) are available for download. Every p-value that was published was two-tailed, with a value of $p < 0.05$ regarded as significant.

RESULTS

The study included 20 patients with knee problem suggesting anterior cruciate ligament (ACL) injury. The majority of the patients (85.0%) were males, while only a small proportion (15.0%) were females. The mean age of the patients was 30.15 years, with a standard deviation of 7.59 years, and the age range of the patients was from 18.0 to 44.0 years.

For complete tears, as per the operative findings in 7 patients, the kappa values were 1.00 for both observers, indicating perfect agreement between DWI/ADC and arthroscopy with sensitivity,

specificity, PPV, NPV, and accuracy values were all 100% for complete tears. Meanwhile as per the follow up clinical diagnoses in the remaining 13 patients the kappa values were 0.581, 0.831 respectively. The sensitivity and specificity were 50, 100 respectively for observer 1 and 1000, 88.9 respectively for observer 2 (table 2).

For partial tears, as per the operative findings in 7 patients, the kappa values were 1.00 for both observers, indicating perfect agreement between DWI/ADC and arthroscopy with sensitivity, specificity, PPV, NPV, and accuracy values were all 100% for partial tears. Meanwhile as per the follow up clinical diagnoses in the remaining 13 patients the kappa values were 0.001, 0.435 respectively. The sensitivity and specificity were 33.3, 50 respectively for observer 1 and 55.6, 100 respectively for observer 2 (table 3).

Inter-observer correlations of the validity of DWI and ADC to conventional MRI between two musculoskeletal radiologists were statistically significant with kappa values were 0.932 for observer 1 and 0.914 for observer 2 (table 4), indicating a high degree of agreement between DWI/ADC and conventional MRI So, the results suggested that DWI/ADC may be a valid alternative to conventional MRI for identifying ACL injuries.

DISCUSSION

Together, the ACL and PCL create a cross, or "x," in the knee to stop the tibia from flexing or extending too far in relation to the femur. When the knee is under varus or valgus stress, the ACL also stabilizes the knee's rotation. ACL sprains and tears are frequent knee injuries; in the US, they are estimated to occur in 100,000 to 200,000 cases annually [8].

Partial tears of the ACL are frequently difficult to diagnose clinically, whereas complete tears can. In certain situations, more testing is required for verification. When a partial ACL tear is diagnosed definitively, clinical information, imaging results, and, if required, arthroscopic findings are combined [9].

On an MRI, ACL damage is easily diagnosed; however, a typical MRI makes it very difficult to tell whether the ACL is partially or totally torn. Future advancements in MRI sensitivity and

specificity for the identification of partial tears should be attainable thanks to the creation of new sequences with oblique views [10].

While the central nervous system (CNS) was the primary target of early diffusion-weighted imaging (DWI) research, more and more study is currently being conducted on other systems as well. There is recorded use of DWI in the musculoskeletal system [11].

Therefore, the goal of the current prospective study was to ascertain how anterior cruciate ligament (ACL) tears are diagnosed and classified as partial or full using diffusion weighted (DW) magnetic resonance imaging (MRI) and to compare it with conventional MRI sequences.

The current study conducted on 20 patients with ACL pathology, who recruited from Ain Shams university hospitals.

Regarding the demographic data Mlv et al. [12] examined the demographic details of patients treated at a tertiary care facility in India for anterior cruciate ligament surgery. He examined total of 124 patients with ACL problem operated for reconstruction. The patients' average age was 27.97 years. Eleven patients (8.9%) were female, while one hundred and thirteen (91.1%) were male. In our study we also concluded that the majority of the patients (85.0%) were male, while only a small proportion (15.0%) were female. The patients ' mean age was 30.15 years.

Arora et al. [7] found that adding DW sequence to conventional MR sequences showed good results in diagnosis and differentiation between complete and partial ACL and PCL tears. The study involved 30 patients with clinically suspected ACL/PCL injuries of the knee and examined the role of DW-MRI in evaluation of ACL and PCL tears. This corroborated our findings that DWI/ADC and MRI had a high degree of agreement. So, we also suggested that DWI/ADC could be a valid alternative to conventional MRI for identifying ACL injuries.

Our findings similarly supported a research by Delin et al. [5] that looked at 85 patients to assess the accuracy and dependability of DW MRI in conjunction with traditional MRI in differentiating between complete and incomplete ACL injuries. According to the study's findings, ADC mapping combined with traditional MRI is a repeatable technique that improves the accuracy of differentiating between complete and partial ACL rupture.

Unlike Park et al. [13], who investigated the value of the quantitative evaluation of DW MRI in the diagnosis of ACL rupture, DWI and ADC mapping sequences were assessed subjectively in both our study and Delin et al.'s [5]. He discovered that there was no difference between the ADC values of the damaged ligament and the normal ligament. He came to the conclusion that as the

sensitivity and accuracy of DW imaging were found to be lower than those of conventional MRI, adding the DWI to the conventional MRI did not improve diagnostic performance.

By comparing the results of MRI and arthroscopy, Zhao et al. [14] discovered that the accuracy rate of MRI in diagnosing a complete tear was 92.86%, and for a partial tear, it was 94.74%. These results were comparable to those of arthroscopic investigation in diagnosing ACL injury, and the diagnostic outcomes were consistent between the two techniques. On the other hand, our study found that as regard validity of DWI and ADC in diagnosis of ACL tears compared to arthroscopy as gold standard, both observers identified one patient as having partial tear while six patients were identified as having complete tears using DWI/ADC, showing perfect agreement between DWI/ADC and arthroscopy. So, the findings imply that DWI/ADC might be a good substitute to conventional MRI for identifying complete ACL tears [Fig 1&2].

According to Chen et al. [15] and Van Dyck et al. [16], prior research indicated that the very high sensitivities and specificities of conventional MRI (ranging from 55% to 98% and 50% to 97%, respectively) in the diagnosis of ACL injury meant that the addition of the DWI could not demonstrate a discernible difference in the diagnostic performance. However, our results showed that conventional MRI showed better agreement than DWI / ADC regarding both complete and partial tears [Fig 3]. In addition, complete tear had better agreement between methods than partial tear, which concluded that the validity of DWI and ADC may be somewhat dependent on the type of tear, as they were useful tools for diagnosing tears, particularly complete tears, but that caution should be exercised when using these techniques to diagnose partial tears.

Our study also agreed with Naraghi A et al. [17] who found that When compared to complete ACL tears, the accuracy of MR imaging for identifying partial tears was much lower, with accuracy rates as low as 25% to 53% and sensitivities and specificities of 62% to 81% and 19% to 97%, respectively,26, 27.28.

Van Dyck et al.'s [16] investigation of the function of three Tesla magnetic resonance imaging (MRI) of the knee ACL in distinguishing between complete and incomplete tears led to the conclusion that MRI at 3.0 Tesla is a very reliable technique for identifying ACL injuries. Even at 3.0 Tesla, it is still challenging to distinguish between complete and incomplete ACL tears and to identify incomplete ligament tears which agreed with our study, in which all the patients were examined using three Tesla MRI machine and yet on comparing to gold standard findings, conventional MRI showed better agreement than DWI / ADC regarding complete and partial tears

[Fig 3]. In addition, complete tear had better agreement between methods than partial tear. Furthermore, the results also suggest that the validity of DWI and ADC may be somewhat dependent on the type of tear, with lower performance characteristic values for partial tears compared to complete tears.

The present study results suggested that the validity of DWI and ADC may be dependent on the observer, as evidenced by the differing sensitivity and specificity values between the two observers. However, both observers achieved high levels of accuracy overall [Fig 4], indicating that DWI and ADC may be reliable tools for diagnosing complete tears. Which agreed with Delin et al. [5] who found that an expert radiologist's reading criteria for typical sequences are relatively constant, although their evaluations differ, leading to interpretive discrepancies. Only one reader, R1, had nearly 100% intra-observer agreement when diffusion mapping was introduced; this was probably due to his greater expertise. When it came to the diffusion sequences, reader 2's intra-observer agreement was still moderate (0.45).

The limitations of our study

Our study had some limitations, and the small sample size was one of them. We might have been able to uncover more meaningful results with a larger sample size. Another limitation was that only few papers found covering this subject which led to lack of satisfactory comparison of our results with other studies. Furthermore, not all of the MRI findings in our investigation had operational confirmation.

CONCLUSIONS

Our research revealed that DWI/ADC yielded comparable results to conventional MRI sequences in identifying full versus partial ACL injuries and diagnosing them and could be a highly valid and reliable tool for diagnosing complete ACL tears yet caution should be exercised when using these techniques to diagnose partial tears.

References

1- **Zhang Q, Yang Y, Li J, Zhang H, Fu Y, Wang Y.** Functional double-bundle anterior cruciate ligament reconstruction using hamstring tendon autografts with preserved insertions is an effective treatment for tibiofemoral instability. Knee Surgery, Sports Traumatology, Arthroscopy. 2019 Nov;27:3471-80.

2- **Evans J, Jl N.** Anterior Cruciate LIgament Knee Injuries.[Updated 2022 May 5]. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. 2022.

3- **Grassi A, Bailey JR, Signorelli C, Carbone G, Wakam AT, Lucidi GA, Zaffagnini S.** Magnetic resonance imaging after anterior cruciate ligament reconstruction: a practical guide. World journal of orthopedics. 2016 Oct 10;7(10):638.

4- **Nenezic D, Kocijancic I.** The value of the sagittal-oblique MRI technique for injuries of the anterior cruciate ligament in the knee. Radiology and oncology. 2013 Mar;47(1):19.

5- **Delin C, Silvera S, Coste J, Thelen P, Lefevre N, Ehkirch FP, Le Couls V, Oudjit A, Radier C, Legmann P.** Reliability and diagnostic accuracy of qualitative evaluation of diffusion-weighted MRI combined with conventional MRI in differentiating between complete and partial anterior cruciate ligament tears. European radiology. 2013 Mar;23:845-54.

6- **Bhojwani N, Szpakowski P, Partovi S, Maurer MH, Grosse U, von Tengg-Kobligk H, Zipp-Partovi L, Fergus N, Kosmas C, Nikolaou K, Robbin MR.** Diffusion-weighted imaging in musculoskeletal radiology—clinical applications and future directions. Quantitative imaging in medicine and surgery. 2015 Oct;5(5):740.

7- **Arora V, Malik S, Singh K.** The Role of Diffusion weighted Magnetic Resonance Imaging in the Evaluation of Anterior Cruciate and Posterior Cruciate Ligament Tears. Indian J Musculoskelet Radiol 2019;1(2):97- 100.

8- **Gupta R, Malhotra A, Sood M, Masih GD.** Is anterior cruciate ligament graft rupture (after successful anterior cruciate ligament reconstruction and return to sports) actually

a graft failure or a re-injury?. Journal of Orthopaedic Surgery. 2019 Feb 19;27(1):2309499019829625.

9- **Temponi EF, Carvalho Júnior LH, Sonnery-Cottet B, Chambat P.** Partial tearing of the anterior cruciate ligament: diagnosis and treatment. Revista brasileira de ortopedia. 2015 Jan;50:09-15.

10- **Sonnery-Cottet B, Colombet P.** Partial tears of the anterior cruciate ligament. Orthopaedics & Traumatology: Surgery & Research. 2016 Feb 1;102(1):S59-67.

11- **Khoo MM, Tyler PA, Saifuddin A, Padhani AR.** Diffusion-weighted imaging (DWI) in musculoskeletal MRI: a critical review. Skeletal radiology. 2011 Jun;40:665-81.

12- **Mlv SK, Mahmood A, Vatsya P, Garika SS, Mittal R, Nagar M.** Demographic characteristics of patients who underwent anterior cruciate ligament reconstruction at a tertiary care hospital in India. World J Clin Cases. 2023 May 26;11(15):3464-3470.

13- **Park HJ, Lee SY, Rho MH, Kim MS, Kwon HJ, Chung EC.** Usefulness of the quantitative evaluation of diffusion-weighted mri in the diagnosis of anterior cruciate ligament tears. J Magn Reson Imaging. 2016 Nov;44(5):1116-1122.

14- **Zhao M, Zhou Y, Chang J, Hu J, Liu H, Wang S, Si D, Yuan Y, Li H.** The accuracy of MRI in the diagnosis of anterior cruciate ligament injury. Ann Transl Med. 2020 Dec;8(24):1657.

15- **Chen WT, Shih TT, Tu HY, Chen RC, Shau WY.** Partial and complete tear of the anterior cruciate ligament. Acta Radiol. 2002 Sep;43(5):511-6.

16- **Van Dyck P, Vanhoenacker FM, Gielen JL, Dossche L, Van Gestel J, Wouters K, Parizel PM.** Three tesla magnetic resonance imaging of the anterior cruciate ligament of the knee: can we differentiate complete from partial tears? Skeletal Radiol. 2011 Jun;40(6):701-7.

17- **Naraghi, A., & White, L. M.** MR imaging of cruciate ligaments. Magnetic Resonance Imaging Clinics. 2014; 22(4), 557-580.

1. F. Bu
2 . ¨ rckenmeyer
3. 1
4 . • I. Diamantis
5. 1
6 . • T. Kriechenbauer
7. 1
8 . • T. Lehmann
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Figure legends

(Figure 1): Male patient, 32 years old with history of left knee twisted injury.

(A) Sagittal SPAIR, MRI of the left knee. The anterior cruciate ligament is showing thickened fibers with high diffuse interstitial signal. (B) sagittal ADC and (C) sagittal DWI revealed thinned yet intact fibers of the ACL with increased signal intensity. Intraoperative findings revealed partial tear.

(Figure 2): Female patient, 29 years old with history of left knee sudden giving way.

(A) Sagittal SPAIR, MRI of the left knee. The anterior cruciate ligament is showing interrupted continuity. (B) sagittal ADC and (C) sagittal DWI revealed ill definition of the fibers of the ACL. Intraoperative findings revealed complete tear.

(Figure 3): Male patient, 20 years old with history of twisting left knee during sports.

(A) Sagittal SPAIR, MRI of the left knee. The anterior cruciate ligament is showing interrupted continuity. (B) sagittal ADC and (C) sagittal DWI revealed thinned yet with few intact fibers of the ACL with increased signal intensity. Lack of improvement on follow up suggested complete tear.

(Figure 4): Male patient, 35 years old with history of sports injury twisted left knee.

(A) Sagittal SPAIR, MRI of the left knee. The anterior cruciate ligament is showing rather thickened fibers yet with preserved fibers continuity. (B) sagittal ADC and (C) sagittal DWI revealed rather thickened yet with intact fibers of the ACL. Improvement on follow up after conservative treatment suggested ACL sprain.

Tables legend

Table 1: MRI protocol parameters.

Table 2: Representing the validity of DWI and ADC in diagnosis of complete tears in comparison to arthroscopic or FU findings as gold standard.

Table 3: Representing the validity of DWI and ADC in diagnosis of partial tears in comparison to arthroscopic findings or FU as gold standard.

Table 4: Representing the validity of DWI and ADC in comparison to conventional MRI as a gold standard.

Table 5: Overall results of DWI / ADC in diagnosis of tears in comparison to arthroscopic and follow up findings as gold standard.

Table 6: Overall validity of DWI / ADC in diagnosis of tears in comparison to arthroscopic and follow up findings as gold standard.

Table 1: MRI protocol parameters

Protocol	TR	TE	FOV	SL	GAP	MATRIX
Sagittal T1	605	14	160	3	0.3	512x256
Sagittal T2	3382	100	160	3	0.3	512x256
Sagittal PD	3100	41	160	3	0.3	512x256
Axial T2	3382	100	160	3	0.3	512x256
Coronal T2 (fat sat)	3070	80	160	3	0.3	512x256
Sagittal SPAIR	3500	110	160	3	0.3	512x256
DWI SAG	4150	79/124	170	1.8	0.2	512x256
SPAIR: Spectral attenuated inversion recovery, PD: Proton density						

Table 2. Validity of DWI and ADC in diagnosis of complete tears in comparison to arthroscopic or FU findings as gold standard.

	Arthroscopic findings				6-12 months follow up clinical outcome			
	Observer 1		Observer 2		Observer 1		Observer 2	
	No complete tear	Complete tear	No complete tear	Complete tear	No complete tear	Complete tear	No complete tear	Complete tear
	№	№	№	№	№	№	№	№
DWI and ADC								
No complete tear	1	0	1	0	9	2	8	0
Complete tear	0	6	0	6	0	2	1	4
P	0.008		0.008		0.021		0.002	
kappa	1		1		0.581		0.831	
Sensitivity (%)	100		100		50		100	
Specificity (%)	100		100		100		88.9	
PPV (%)	100		100		100		80	
NPV (%)	100		100		81.8		100	
Accuracy (%)	100		100		84.6		92.3	

*: Significant when p value<0.05

Table 3. Validity of DWI and ADC in diagnosis of partial tears in comparison to arthroscopic findings or FU as gold standard.

	Arthroscopic findings				6-12 months follow up clinical outcome			
	Observer 1		Observer 2		Observer 1		Observer 2	
	No partial tear	partial tear	No partial tear	partial tear	No partial tear	partial tear	No partial tear	partial tear
	№	№	№	№	№	№	№	№
DWI and ADC								
No partial tear	6	0	6	0	2	6	4	4
Partial tear	0	1	0	1	2	3	0	5
P	0.008		0.008		0.569		0.105	
kappa	1		1		0.001		0.435	
Sensitivity (%)	100		100		33.3		55.6	
Specificity (%)	100		100		50		100	
PPV (%)	100		100		60		100	
NPV (%)	100		100		25		50	
Accuracy (%)	100		100		38.5		69.2	

*: Significant when p value<0.05

Table 4. Validity of DWI and ADC in comparison to conventional MRI as a gold standard.

Conventional MRI							
		Observer 1			Observer 2		
		Partial tear		Complete tear	Partial tear		Complete tear
		Intact (sprain)	Partial thickness tear		Intact (sprain)	Partial thickness tear	
		№	№	№	№	№	№
DWI and ADC		.					
Partial tear	Intact (sprain)	6	0	0	3	0	0
	Partial thickness tear	0	4	2	1	5	0
Complete tear		0	0	8	0	1	10
P		<0.001*			<0.001*		
kappa		0.932			0.914		

*: Significant when p value<0.05

Table 5. Overall results of DWI / ADC in diagnosis of tears in comparison to arthroscopic and follow up findings as gold standard.

	Arthroscopy and follow up		**DWI & ADC**			
	Observers 1 and 2		**Observer 1**		**Observer 2**	
	№	**%**	**№**	**%**	**№**	**%**

Partial tear	10	50	12	60	9	45
Complete tear	10	50	8	40	11	55
Total	20	100	20	100	20	100

Table 6. Overall validity of DWI / ADC in diagnosis of tears in comparison to arthroscopic and follow up findings as gold standard.

Gold standard	**Arthroscopic**		**Follow up**	
	DWI and ADC		**DWI and ADC**	
	Complete tear	**partial tear**	**Complete tear**	**partial tear**
Sensitivity (%)	100.0	100.0	75.0	44.4
Specificity (%)	100.0	100.0	94.4	75.0
PPV (%)	100.0	100.0	85.7	80.0
NPV (%)	100.0	100.0	89.5	37.5
Accuracy (%)	100.0	100.0	88.5	53.8