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A study to detect venous perforators in lower limbs by MRI & TRUEFISP

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Abstract
Background: Venous pathology of the lower extremities is a critical public health problem with economic and social consequences. It includes scenarios from minor varicose veins (VVs) and venous static ulcers (SUs) to potentially deadly deep vein thrombosis (DVT)
Methodology: A study was conducted at SSIMS & RC, Davanagere, Karnataka between June 2019 and June 2020, to find the capability of MRI in detecting the incompetent perforators.60 patients (including 24 males and 36 females) reported with clinical diagnosis of varicose veins underwent Colour Doppler examination followed by MRI lower limbs, and TRUEFISP fat sat sequences.
Results and Discussion: In our study 60 patients underwent both Colour Doppler and corroborative MRI. There were 36 females and 24 males. A total of 78 legs were assessed as bilateral legs were evaluated in 18 patients. There were total 162 perforators including 112 incompetent ones and 50 competent ones. All the perforators greater than 1.8 mm were detected in MRI and 77 of them were greater than or equal to 2.0 mm in diameter.
Conclusion: In this study results shows that any perforator more than or equal to 2.8 mm has got a positive predictive value of more than 95 percentage for being incompetent and any perforator more than or equal to 3.4 mm has got a 100 percentage positive predictive value for being incompetent.

Keywords: MRI, colour doppler examination, perforator, TRUEFISP

Introduction

The ability of MR imaging to depict flow, in combination with the inherent soft tissue contrast, has led to the rapid clinical implementation of this modality for vascular imaging. Slower flow and more homogeneous flow profiles make MR venography technically less demanding than MR arteriography. Since venous pathology usually tends to be more extensive, high resolution MR imaging is not required for routine MR venography to the same extent as it is needed for imaging of the arterial system. Conventional time-of-flight (TOF) and phase contrast (PC) MR techniques, which do not require the use of a paramagnetic contrast agent, have therefore evolved as reliable and clinically accepted methods for assessment of the venous system. However, these techniques do have limitations in that they are susceptible to pulsatility, in-plane saturation effects, and spin dephasing when laminar flow is disturbed. Furthermore, lengthy acquisition times coupled with the technique's inability to reliably display small deep veins in the calf or superficial and perforating veins running horizontal to the imaging plane have restricted the routine clinical application of conventional MR techniques [1].

Venous pathology of the lower extremities is a critical public health problem with economic and social consequences. It includes scenarios from minor varicose veins (VVs) and venous static ulcers (SUs) to potentially deadly deep vein thrombosis (DVT) [2-4]. Ultrasonography serves as the standard first-line tool for evaluating lower limb swelling. However, ultrasonography is both difficult and insensitive in patients exhibiting obesity, oedema, or tenderness who have undergone recent hip or knee arthroplasty as well as those with casts, bandages, or immobilization devices. Ultrasonography also does not adequately assess the pelvic region or the deep veins [5]. Previously, conventional venography was considered the standard tool for the detection of DVT in patients with VVs [6-7]. However, this procedure is time-consuming and invasive and requires the use of contrast medium and radiation exposure. Contrast enhanced computed tomography (CT) and magnetic resonance imaging (MRI) have been widely discussed and used in clinical practice. However, the complications

Associated with contrast agents are concerning and can be fatal. Nephrogenic systemic fibrosis (NSF) is a rare but severe complication of using gadolinium-based contrast agents in patients with renal insufficiency [8-10].

Colour Doppler study is the accepted imaging modality of choice in localizing perforator veins of lower limbs and diagnosing their incompetence. However it is very laborious to detect perforators using Colour Doppler, as the fields of view is very small. Colour Doppler is also operator dependent. Also the images of entire study cannot be stored. MRI is non operator dependent and gives a large field of view. The entire set of images can be provided and are available for review. These advantages of MRI can be made useful for interventional radiological treatment plans like foam sclerotherapy. Moreover the MRI protocol used for the study doesn't necessitate any kind of contrast administration. There is no known study done till date to assess the role of MRI in detection of venous perforators in lower limbs.

(i) To compare the positive predictive value and sensitivity of MRI with that of Colour Doppler in localization of perforators of lower limbs.
(ii) To determine effect of addition of MRI to Colour Doppler, in the evaluation of varicose veins.

Methodology

The study was conducted on 60 subjects.

The study conducted at SSIMS & RC, davanagere, Karnataka between June 2019 and June 2020. All cases referred for Doppler study of lower limbs presenting, with clinical diagnosis of varicose veins were taken up for this study.

Cases were included in the study after taking consent.

Ethical clearance was taken from the institutional ethical committee

Inclusion Criteria

1. Patients with a clinical diagnosis of varicose veins
2. Patients willing to undergo additional investigation of MRI

Exclusion Criteria

1. Individuals with contraindication to MRI
2. Unwilling patients.
3. Claustrophobic patients
4. Pregnancy

Method of Collection of Data

The patients were examined in a standing position clinically for superficial varicosities, followed by Colour Doppler evaluation using 7-12 Mhz probe. Appropriate probe settings were adjusted which are suitable for each patient. Any perforator which showed a reflux invalsalva (Sustained reflux for more than 3 seconds) was considered incompetent in appropriate clinical setting, keeping the Colour Doppler study as the gold standard in detection of incompetent perforators. Measurements were obtained by using a GE LogiqP5 ultrasound machine (Fig-1) in real time 2D image.

Fig 1: GE LOGIQ P5 Ultrasound machine

Such patients who fulfilled inclusion criteria for MRI study were reviewed in Siemens magneto avanto 1.5 T machine(Fig-6) by TRUEFISP axial sequences(TR-3.64, TE-1.57, Slice thickness 3.0 mm with Distance factor -0, Phase encoding direction- Anterior>Posterior) of lower limbs in lying position.

Fig 2: Magnetom Avanto 1.5 T MRI Machine

The incompetent perforators detected in Colour Doppler were corroborated in MR images forits capability of getting detected, caliber and course. The maximum diameter of each incompetent perforator was measured for assessment. Efforts were made to set a criteria by size in MRI for any incompetent perforator detected in Colour Doppler. The variation in size of same incompetent perforator may occur as the patients are usually examined in standing position in Colour Doppler and lying position in MRI. The mean and minimum caliber of incompetent perforators identified in MRI (Which are corroborated with Colour Doppler) were calculated and sensitivity and specificity of MRI for detection of incompetent perforators were identified for each standards.

Statistical analysis

A Data collection Proforma was designed at the start of the study. The data obtained during the study, was compiled in to the preset format (Annexure III) to maintain uniformity and aid easy recall and review.

Descriptive and inferential statistical analysis has been carried out in the present study.
Results on continuous measurements are presented on Mean +/- SD (Min-Max) and results on categorical measurements are presented in Number (%).
Significance is assessed with positive predictive values.
Statistical software: The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, Med Calc 9.0.1, Systat 12.0 and R environment ver.2.11.1 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc. (62,63,64).

Results

Table 1: Comparing the diameter of the perforator {Mean (SD)} among both the test groups (Positive and negative)

	Reflex	N	Mean	Std. Deviation	Std. Error Mean
Diameter	Present	66	5.1145	.81629	.21382
	Absent	35	3.1828	.72616	.13718

Table 2: Independent Samples Test

Levine's Test for Equality of Variances			t-test for Equality of Means						
	F	Sig.	t	DF	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal Variances Assumed Diameter	14.589	.001	9.014	82	.000	2.18916	.18173	.98108	1.8141
Equal variances not assumed			11.31	79.1	.000	1.31676	.14216	1.1618	1.6171

Table 3: Sensitivity and specificity analysis (ROC curve)

Reflux	Valid N (list wise)
Positive	66
Negative	35

Table 4: Area Under the Curve Test Result Variable(s): Diameter

Area	Std. Error	Asymptotic Sig. b	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.982	.031	**.000**	.890	.986

Table 5: Positive predictive value and sensitivity of being a perforator Incompetent at different diameters

Diameter Greater Than or Equal Toa	Positive predictive value	Sensitivity
2.2 mm	0.802	0.841
2.3 mm	0.842	0.788
2.4 mm	0.868	0.758
2.5 mm	0.895	0.731
2.6 mm	0.910	0.711
2.7 mm	0.945	0.691
2.8 mm	0.962	0.681
2.9 mm	0.959	0.671
3.0 mm	0.958	0.658
3.1 mm	0.974	0.638
3.2 mm	0.978	0.634
3.3 mm	0.978	0.609
3.4 mm	1.00	0.598
3.6mm	1.00	0.579

Discussion

MRI is able to show thigh and leg veins very clearly and can be used to assess the effects of body position and of compression. Duplex investigations have demonstrated that the narrowing effect of external compression depends very much on the body position.5 This is of crucial interest since the reduction of venous diameter is one of the prerequisites for a hemodynamic efficacy of compression therapy playing a role for thromboprophylaxis as well as for the improvement of venous pumping function in patients with venous reflux. Some unexpected observations presented here need further corroboration. The peculiar finding that compression may narrow deep veins more than superficial veins was observed especially in the prone and in the standing position. In 8 healthy volunteers Downie *et al.* described a mean cross-sectional area reduction by travel socks to be greater in the deep veins (64%) than in the superficial veins (39%). All investigations in this series were performed in the prone position [11-12].
Intravenous ultrasonography (IVUS) is a new imaging modality for diagnosing deepvein disease and is mostly guiding effective endovascular treatment in iliac and cavalvenous obstructive lesions [13]. However, IVUS is invasive and only provides details of the venous lumen without information of the superficial venous system. Venography was considered as standard for the detection of deep venous thrombosis and other venous occlusive diseases, but venography cannot display the superficial veins outside the drainage course of the contrast-media injection site. CT venography may be useful for the exclusion of pulmonary embolism in patients with signs of deep venous thrombosis in the legs; however, CT venography also requires the injection of contrast media in the morbid limb to achieve optimal venous imaging of the extremities, which can be dangerous for the diseased limb [14]. Magnetic resonance angiography (MRA) techniques for reconstructing vascular structures include time-of-flight (TOF), phase-contrast, and ECG-gated TSE MRA. The major disadvantage of TOF-MRV is that the FOV is small for each image obtained and that it requires considerable time to image the whole lower extremity. MRI with gadolinium-based contrast media is a relatively rapid method for imaging of the lower extremities [15, 16]. Although MRI does not involve radiation exposure, the non-iodinated contrast agents involved in the process have undesirable effects on the patients. For instance, nephrogenic systemic fibrosis is a dangerous condition caused by exposure to gadolinium-based contrast agents in patients with pre-existing impairment of kidney function and even in patients with normal renal function [17, 18].
In our study 60 patients underwent both Colour Doppler and corroborative MRI. There were36 females and 24 males. A total of 78 legs were assessed as bilateral legs were evaluated in 18 patients. There were total 162 perforators including 112 incompetent ones and 50 competent ones. All the perforators greater than 1.8 mm were detected in MRI and 77 of them were greater than or equal to 2.0 mm in diameter. The mean diameter of incompetent perforators was 3.57 and that of competent perforators was 2.27.The least diameter of any incompetent perforator detected in

study was 2.2 mm and maximum diameter of any competent perforator is 3.3 mm. In other words all the perforators with a diameter of more than 3.3 mm in MRI are incompetent and all the perforators below 2.2 mm in MRI are found to be competent.

There were total 44 perforators with diameter between 2.2 and 3.3. 14 of them were competent and 8 of them incompetent.

As per the study any perforator with a diameter of 3.3 mm or more in MRI are definitely incompetent and any perforator with a diameter of 2.2 mm or less are definitely competent.

The study results shows that any perforator more than or equal to 2.8 mm has got a positive predictive value of more than 95 percentage and any perforator more than or equal to 3.4 mm has got a 100 percentage positive predictive value.

The findings of present study reveal that even though MRI cannot replace Colour Doppler in confirming the competency of perforators, it is an adjuvant to Doppler especially in those cases planned for Foam sclerotherapy. It’s non operator dependent and entire set of images is available for review and far easier to assess. The role of MRI in comparing with previous imaging and follow up of the patient is far superior to Colour Doppler. The perforators are well visualized and cut off diameter of the incompetent perforators can be used as a criteria to determine if it is competent or incompetent. Any perforator leading to superficial varicosities can be another clue towards incompetence. Such perforators can be evaluated again in Colour Doppler and confirmed for its competency, which in fact makes the laborious Colour Doppler evaluation into an easier one.

REPRESENTATIVE IMAGES

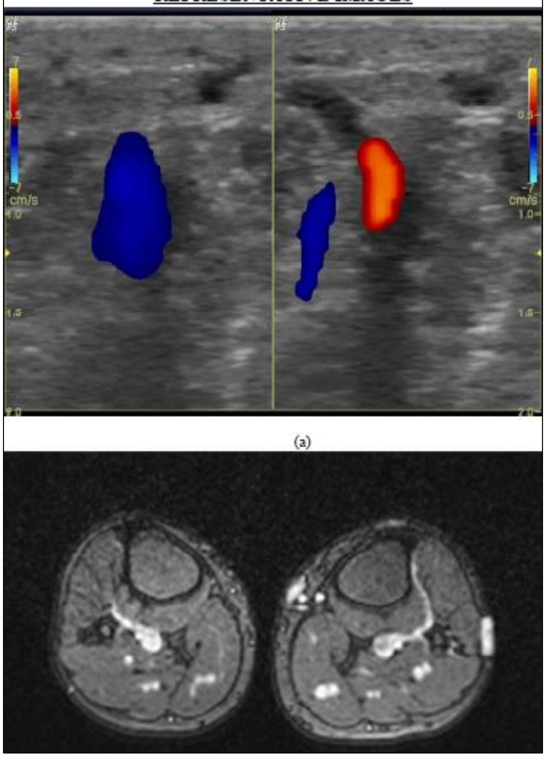

Fig 3: (a) Above:- Colour Doppler image of an incompetent perforator at 17 cms above Left lateral malleolus, anterolaterally at rest(Left) and during valsalva (Right) showing reversal flow /Reflux (From blue at rest to red at valsalva -> 3 Seconds). (b) Below:- Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 2.3 m.

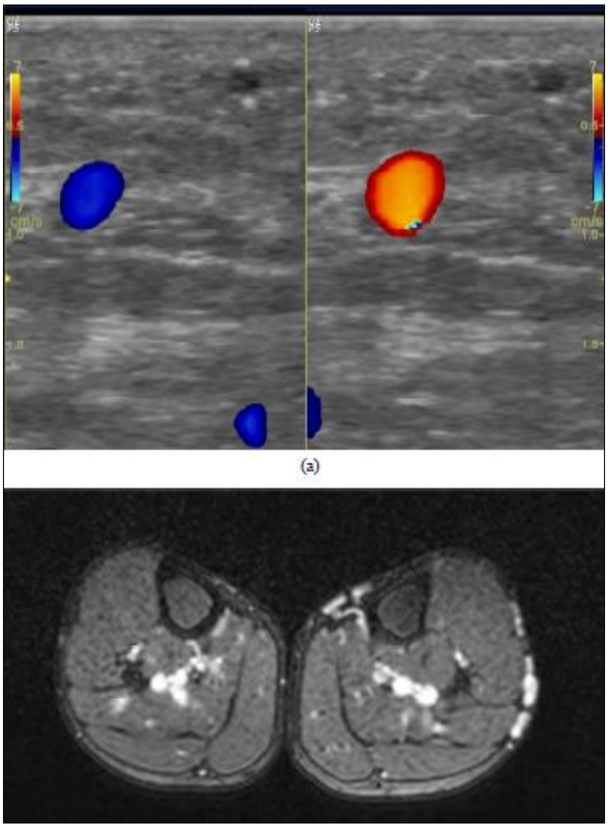

Fig 4: (a) Above:- Colour Doppler image of an incompetent perforator at 3 cm above Left medial malleolus at rest(Left) and during valsalva(Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds).(b)Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 2.5 mm.

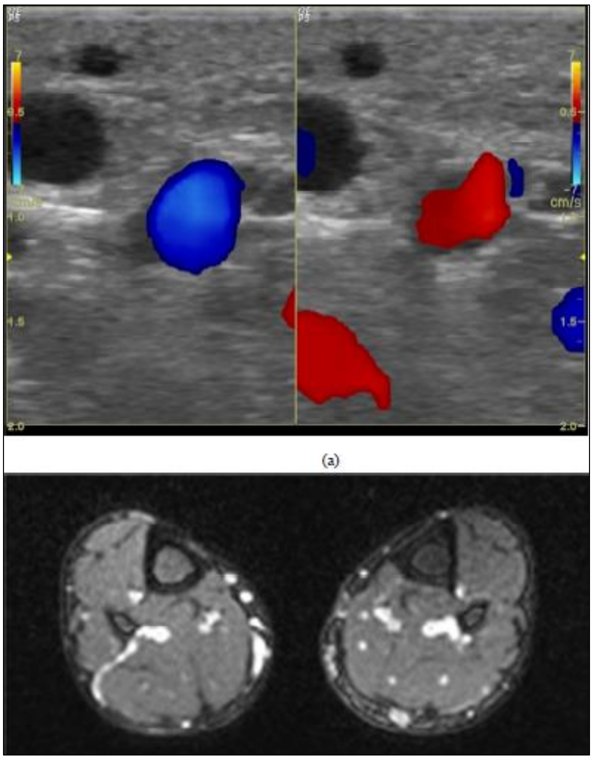

Fig 5: (a) Above:- Colour Doppler image of an incompetent perforator at 2 cm below Right knee posterolaterally at rest(Left) and during valsalva (Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds). (b) Below:- Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 3.0 mm.

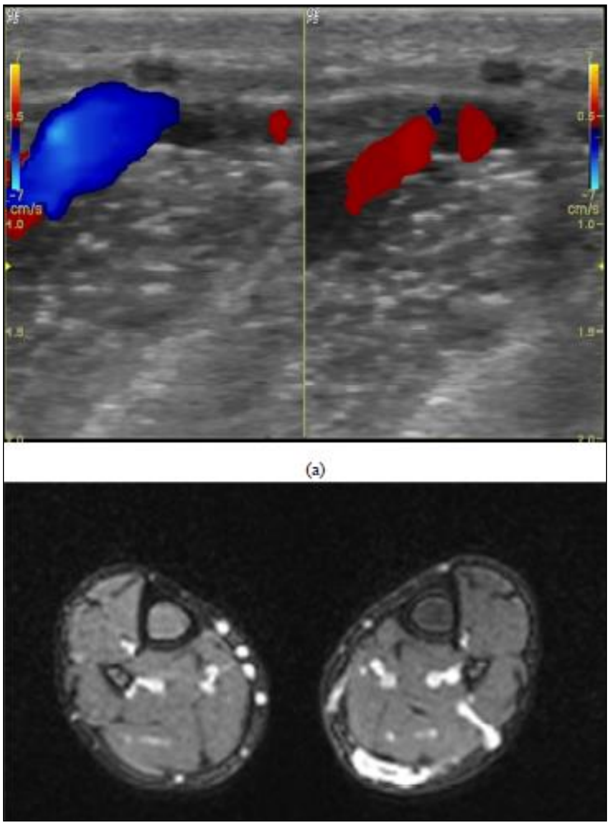

Fig 6: (a) Above:- Colour Doppler image of an incompetent perforator at 12 cms above Left lateral malleolus at rest(Left) and during valsalva(Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds).(b)Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 3.4 mm.

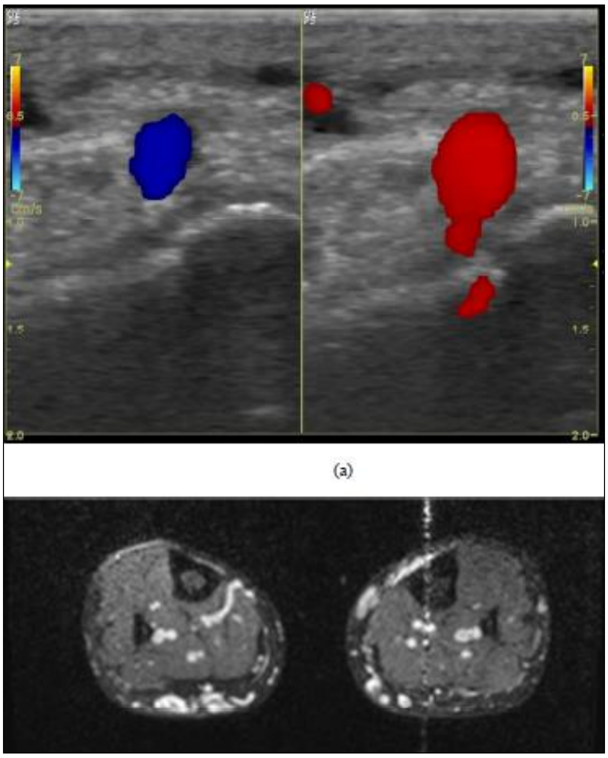

Fig 7: (a) Above:- Colour Doppler image of an incompetent perforator at 15 cm above Right medial malleolus at rest (Left) and during valsalva(Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds). (b) Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 3.5 mm.

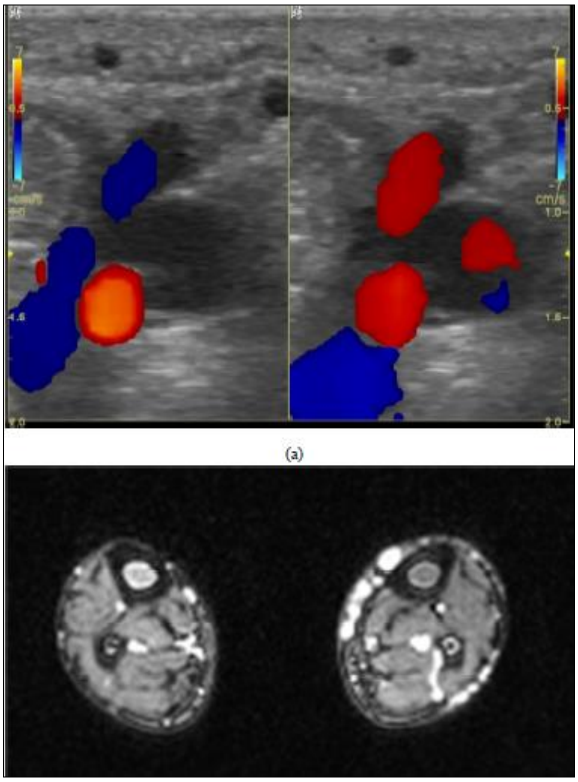

Fig 8: (a) Above:- Colour Doppler image of an incompetent perforator at 6 cm below Left knee posteriorly at rest(Left) and during valsalva(Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds).(b)Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 3.9 mm.

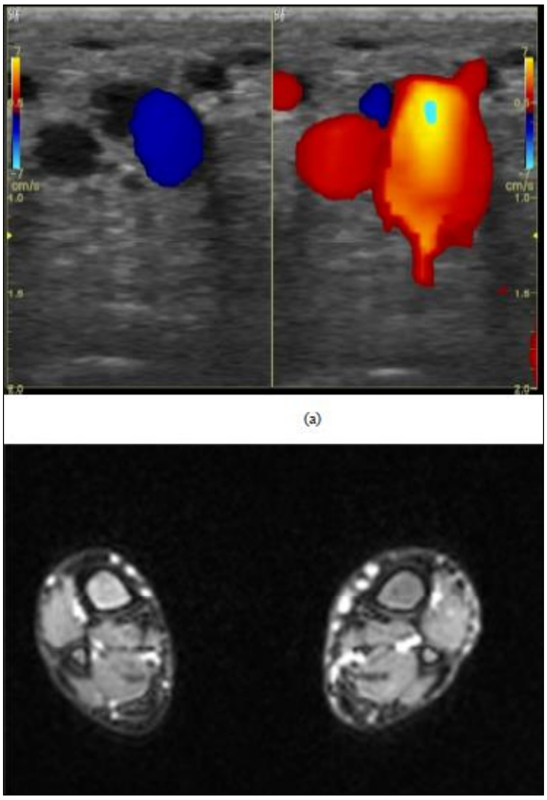

Fig 9: (a) Above:- Colour Doppler image of an incompetent perforator at 13 cms above Left medial malleolus posteromedially at rest(Left) and during valsalva(Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds).(b)Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 4.0 mm.

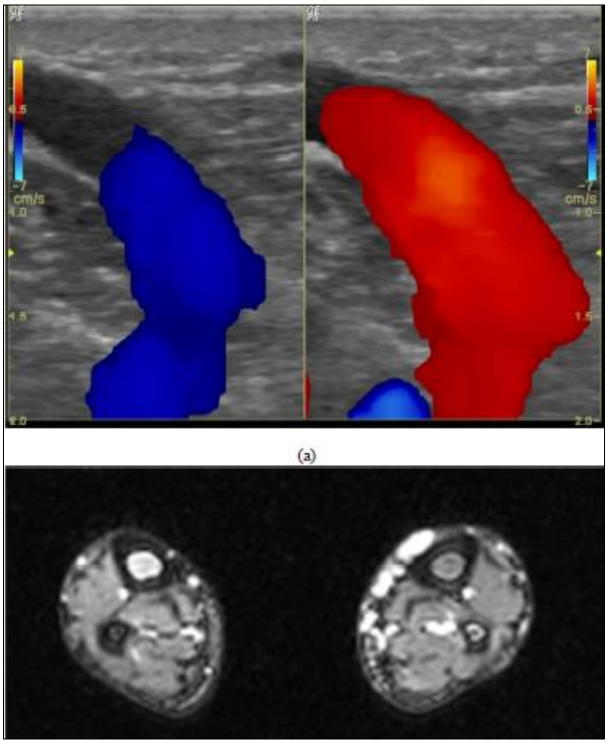

Fig 10: (a) Above:- Colour Doppler image of an incompetent perforator at 7 cms above Left medial malleolus medially at rest(Left) and during valsalva(Right) showing reversal flow /Reflux (From blue at rest to red at valsalva-> 3 Seconds).(b)Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 4.1 mm.

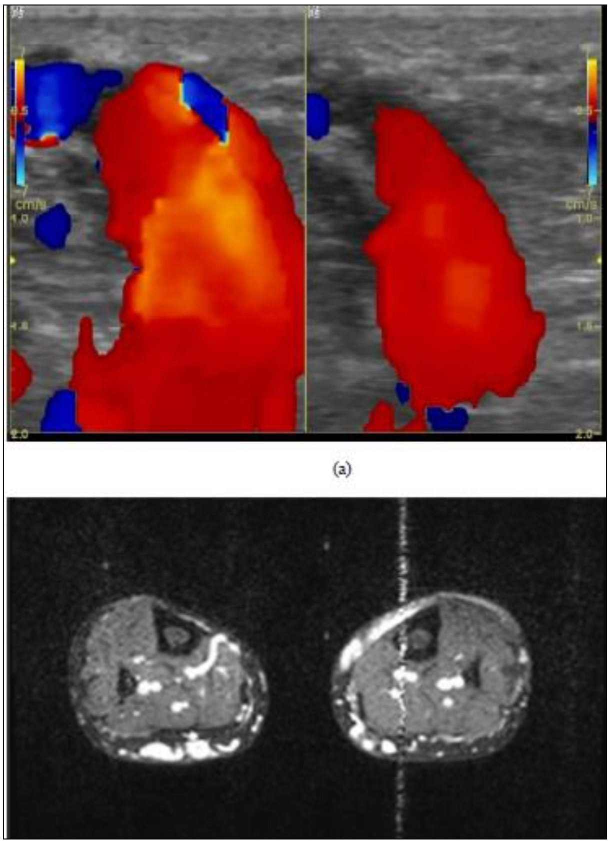

Fig 11: (a) Above: Colour Doppler image of an incompetent perforator at 5 cms above Right medial malleolus at rest(Left) and during valsalva (Right) showing continuous reversal of flow (Both at rest and valsalva).(b)Below:-Corroborative MRI (TRUEFISP Fat sat axial sequence) showing the perforator with a diameter of 4.8 mm**.**

Conclusion
Addition of MRI to the Colour Doppler in assessment of incompetent perforators in assessment of varicose veins is of tremendous importance especially in those patients planned for Foam Sclerotherapy. In this study results shows that any perforator more than or equal to 2.8 mm has got a positive predictive value of more than 95 percentage for being incompetent and any perforator more than or equal to 3.4 mm has got a 100 percentage positive predictive value for being incompetent.

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Conflict of Interest
None

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