Colour Doppler Imaging Of Orbital Vessels in Patients With and Without Diabetic Retinopathy

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I. Introduction

The course of Diabetes Mellitus (DM) is associated with metabolic disorders in various organs, including intraocular tissue structures. Diabetic Retinopathy (DR) is a form of microangiopathy, and is the most common ocular complication seen in diabetic patients these days. An average of 5-10 years is given for this complication to occur. Diabetic retinopathy affects 80% of patients affected with Type I DM and nearly 85% of patients with Type II DM. It is estimated that 8.3% of the world's population are affected with diabetes mellitusand about half of them are affected with diabetic retinopathy at any given point of time. In the developing and developed countries, it represents the main cause of blindness between 20-75 years of age. In India with the increase in Type II diabetes mellitus as reported by the World Health Organization (WHO), one of the fast progressing cause of visual disability is diabetic retinopathy. The severity of hyperglycaemia is considered as the key risk factor for developing retinopathy. Along with this, duration of diabetes is known as the next possible risk factor.Previous studies suggested that most patients with Diabetes develop characteristic abnormalities of retinal blood vessels which include retinal capillary blood obstructions, capillary dropouts, microaneurysms, venous abnormalities, neovascularization and blood rheologic abnormalities in the orbital vessels. These abnormalities seem to alter the retinal microcirculation and reduce the retinal blood flow. The introduction of orbital Colour Doppler Imaging (CDI) in 1989 by Erickson et al. presented the opportunity for assessment of orbital blood vessels and to see the vessel changes. CDI is a safe, non invasive and easily reproducible method for evaluating hemodynamic alterations in severe orbital and retinal vascular diseases. Orbital vessels may easily be identified because the Doppler shift is encoded in colour and is superimposed on the two dimensional, grey-scale ultrasoundimage. Thus, even vessels below resolution of a grey-scale image can be visualized. In contrast to conventional Doppler techniques, Colour Doppler Imaging makes it possible to evaluate separately, vessels that are directly adjacent. In this way, the circulation of the Ophthalmic Artery (OA), Central Retinal Artery (CRA) and Short Posterior Ciliary Artery (SPCA) may be investigated. Assessment of blood flow velocities, including Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV) and Resistive Index(RI) which is a measure of peripheral vascular resistance, is calculated for each retrobulbar vessel at the same time. Very few studies have been performed on this topic outside India hence the purpose of this study is to evaluate Resistive changes in the peripheral ocular vascular bed that may contribute to the initiation and progression of diabetic retinopathy and to assess the usefulness of Colour Doppler sonography for differentiating patients with and without diabetic retinopathy.

II. Aims and Objectives

1. The aim of this study is to evaluate hemodynamic changes of Ophthalmic Artery (OA), Central Retinal Artery (CRA) and Short Posterior Ciliary Artery (SPCA).
2. To compare the hemodynamic changes of OA, CRA and SPCA in Diabetic patients with Retinopathy and controls.
3. To compare the hemodynamic changes of OA, CRA and SPCA in Diabetic patients without Retinopathy and controls.
4. To compare the hemodynamic changes of OA, CRA and SPCA in Diabetic patients without Retinopathy and patients with Diabetic retinopathy.
5. To compare the Resistive Index of OA, CRA and SPCA in patients with and without Diabetic retinopathy.
6. To find the use of Colour Doppler Imaging in differentiating diabetic patients with retinopathy from those

withoutretinopathy.

7. To assess the monitoring potential of Colour Doppler Imaging in the progression of diabetes and diabetic retinopathy.

Colour Doppler Imaging (CDI) is a safe, non invasive and highly reproducible procedure for evaluating hemodynamic alterations in the blood vessels. Colour Doppler Imaging (CDI) combines two dimensional (2D) ultrasonography with Doppler spectral analysis to evaluate the vascular structures and blood flow velocities.

Colour Doppler Imaging

Ultrasonic colour Doppler imaging is a technique that combines anatomical information derived using ultrasonic pulse-echo techniques with the velocity information derived using ultrasonic Doppler techniques to generate colour-coded maps of tissue velocity superimposed on grey-scale images of the tissue anatomy. The most common use of the CDI technique is to image the movement of blood through the heart, arteries and veins. It can also be used to image the motion of solid tissues such as the heart walls. CDI is now provided on almost all commercial ultrasound machines, and has been found to be of great importance in assessing blood flow in many clinical conditions. All types of Doppler ultrasound equipment employs filters to cut off the high amplitude, low-frequency Doppler signals due to the tissue movement, for instance due to vessel wall motion. Filter frequency can usually be altered by the user, to exclude frequencies below 50, 100 or 200 Hz. This filter frequency limits the minimum flow velocities that can be measured.

Indices of Measurement

(1) Resistance index (RI) or Pourcelot's index
(2) Systolic/diastolic (S/D) ratio, also called the A/B ratio
(3) Pulsatility index (PI)

RI = PSV-EDV/PSV (Pourcelot, 1974)
PI= PSV-EDV/ Temporal Average Frequency over 1 cardiac cycle (Gosling, 1976)
S/D Ratio: PSV/EDV (Stuart &Drumm, 1980)

Resistive Index is not altered by the angle of Doppler since it is a ratio, but V_{max} & V_{min} are altered by the angle of Doppler. RI is a useful measure to study the difference between various groups of patients & also avoid any inter observer bias.

Colour Doppler Imaging In Diabetic Retinopathy

Colour Doppler Imaging is a relatively new technique that has come to use in Ophthalmology. It is useful in assessing the qualitative and quantitative blood flow velocities in various orbital blood vessels. CDI provides reliable information on blood flow velocities at sites of complex vasculature by using Doppler and B scan images simultaneously. CDI can easily image OA and PCA as these vessels are inaccessible by Fundus Fluorescein Angiography or laser Doppler velocimetry. It can also image CRA when fundus view is hazy on examination by ophthalmoscope. The morphologic and vascular information in various ophthalmic diseases such as diabetic retinopathy, hypertensive retinopathy, glaucoma, Ocular Ischemic Syndrome and orbital tumors can be assessed. Blood flow velocities and RI can be evaluated in each stage and grading of diabetic retinopathy. It is a useful in measuring the progression and severity of diabetic retinopathy. It can be used in detecting the flow velocities post pan retinal photocoagulation. Resistive Index is an indirect measurement of blood flow resistance that can be used to evaluate vascular damage in ophthalmologic diseases. The RI is said to be a measure of vascular resistance in the artery and is a useful parameter when compared to PSV and EDV. The circulation of Ophthalmic Artery (OA), Central Retinal Artery (CRA), branches of Posterior Ciliary Arteries (PCA), Superior Ophthalmic Vein, Central Vein and sometimes under favourable conditions even different Vortex Veins can be identified. Blood flow velocities in orbital vessels in conditions causing states of decreased flow such as Diabetic retinopathy, hypertensive retinopathy and ocular ischemic syndrome can also be assessed. The PSV, EDV and RI which is a measure of peripheral vascular resistance, is calculated for each retrobulbar vessel at the same time.

III. Materials And Methods

This study was conducted among patients referred from outpatient departments like ophthalmology, medicine and surgery to department of Radiology with complaints of diabetes and diabetic retinopathy at Meenakshi Medical College and Hospital and Research Institute, Kanchipuram,. It was conducted for a period of 2 years, from December 2012 to September 2014. A total of 60 patient were included among which 30 male and 30 female patients were taken into this study. An average age group of 50-80 years. An informed consent, oral and written was obtained from every patient. The patient's attender was also explained about this study and assured that it was a harmless non invasive procedure. Patients were then taken to ophthalmology department and categorized into 3 groups according to their fundus examination and was brought back to the Department of Radiology to undergo Colour Doppler Imaging. GE VOLUSON S6 PRO ultrasound machine was used

throughout the study with 7.5 MHz sector transducer probe for examining CRA, OA and SPCA in both eyes of the patient. Diabetic retinopathy is a bilateral condition. The grading and severity of retinopathy is almost the same in both the eyes. But, there are cases in which one eye maybe affected more than the other. There can be a disparity in the visual acuity of both the eyes. This can be due to improper medication and fluctuating blood sugar levels. Hence both the eyes of the patients are taken under study in Colour Doppler Imaging. The radiologist performing the Colour Doppler Imaging was blinded regarding the diagnosis of the patient to avoid any bias.

INCLUSION CRITERIA

- Normal patients having normal blood glucose and normal blood pressure levels volunteering for the study.
- Diabetic patients with duration of disease from 2-15 years.
- Diabetic patients without manifestations of diabetic retinopathy.
- Diabetic patients with diabetic retinopathy (Grades of moderate and severe non-proliferative diabetic retinopathy and proliferative diabetic retinopathy according to Early Treatment Diabetic Retinopathy Study criteria).
- Age group of 50-80 years.
- Both sexes were included in the study.

EXCLUSION CRITERIA

- Patients with history of congenital orbit pathology, trauma, infections or inflammatory lesions, benign or malignant lesions in orbit and cerebrovascular insult or CVA.
- Patients with hypertension/ dyslipidaemia/ glaucoma.
- Patients with history of smoking
- Patients with intake of drugs causing vasodilatation.
- Patients with previous history of Intra Ocular Surgery
- Patients who underwent laser procedures.

BREIF PROCEDURE:
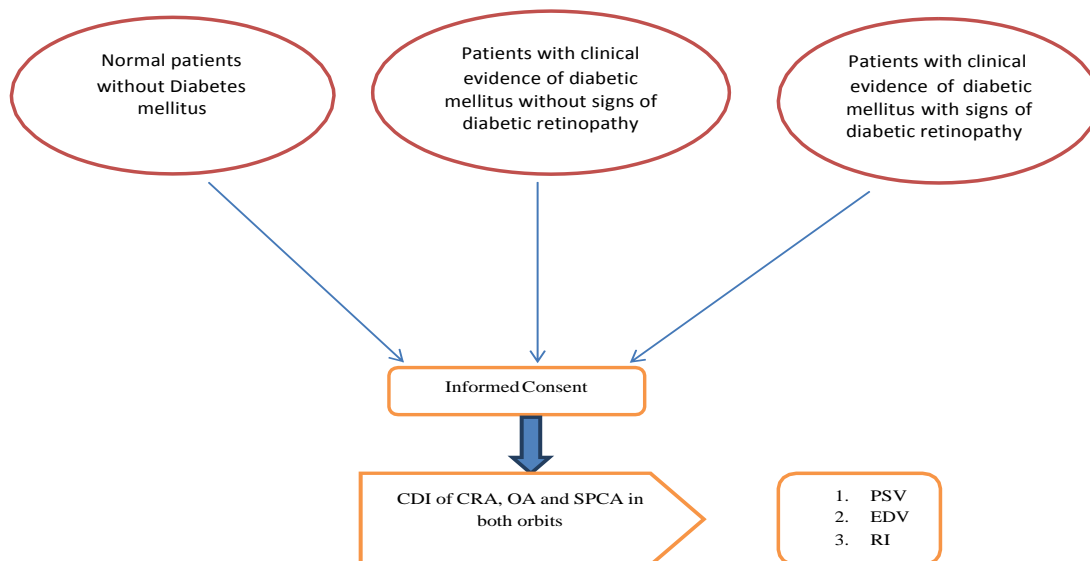
A total of 60 patients were included of which 20 were normal individuals used as controls. They were age matched. Informed and written consent obtained from patients.

IV. Results

- **DESCRIPTIVES**

Table 1: Group Of Patients Studied

Group	No. of eyes	%
Control Group (A)	40	33.3
Diabetic patients without retinopathy (B)	40	33.3
Diabetic patients with diabetic retinopathy (C)	40	33.3
Total	120	100.0

The total number of subjects included in this study is 60. Each group containing 20 patients. Both eyes were examined under this study. Hence there are a total of 120 eyes with 40 eyes in each group.
The distribution of patients under each group in the present study is depicted in Table 1.

**Table 2: Gender Distribution Of 60 Patients**

Gender	No. of patients	%
Female	30	50
Male	30	50
Total	60	100.0

Male participants in this study is 50% (30 cases) and female participants is 50% (30 cases)
The distribution of patients by gender group in this present study is depicted in table 2

Figure 1: AGE DISTRIBUTION OF PATIENTS IN THE PRESENT STUDY
Out of 60 patients in the study, there are 20 patients in the age group of 51-60years, 20 patients in 61-70 years and 20 patients in 71-80 years.
The distribution of patients by Age group in this present study is depicted in Fig 1
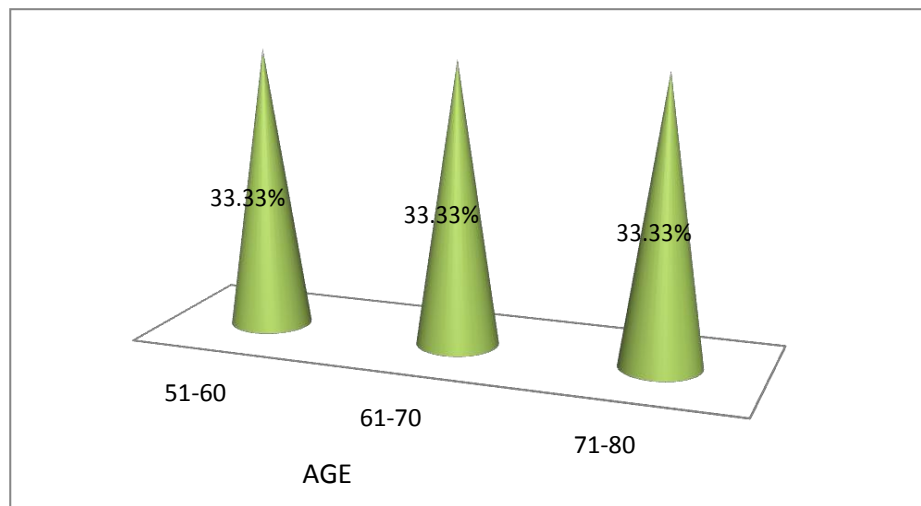
- **STATISTICAL ANALYSIS**

Table 3: Comparison Of Psv Among The Orbital Vessels In Each Group

Artery	Group A	Group B	Group C
Central Retinal Artery	0.139±0.003 Aa	0.123±0.004 Ab**	0.110±0.002 Ac**
Ophthalmic Artery	0.323±0.004 B**a	0.343±0.003 B**b**	0.356±0.001 B**c**
Short Posterior Ciliary Artery	0.162±0.002 C**a	0.128±0.004 Ab**	0.105±0.004 Ac**

Means bearing same superscript do not differ significantly
Data   : Mean± S.E (Standard Error)
Group A : Control
Group B : Diabetes without Retinopathy
Group C : Diabetes with Retinopathy Uppercase superscript   : Comparison within the group Lowercase superscript   : Comparison between the groups
*Signifiant (P ≤ 0.05); ** Signifiant (P ≤ 0.01)*
The above table shows the PSV of all three vessels under each group.

In CRA, the PSV is seen to be significantly reduced in Group B & C when compared to Group A. The PSV is least in Group C which implies that the blood flow velocity is significantly reduced in patients with diabetic retinopathy when compared to the controls.

In OA, the PSV is seen to be significantly increasing in Group B and C when compared to Group A.

The PSV is significantly maximum in Group C which implies that the blood flow velocity is more in patients with diabetic retinopathy when compared to patients without retinopathy and controls.

In SPCA, there is a decrease in PSV in Group B and C when compared with Group A. It is significantly reduced in Group C which implies that the blood flow velocity is least in the patients with diabetic retinopathy when compared to patients without retinopathy and controls.

In Group B it is found that the PSV of CRA and SPCA are almost the same and the decrease seen are almost the same within the group but not between the groups. In Group C the PSV of CRA and SPCA are consistent with each other and there is a steady decrease when compared to Group B and the PSV of OA in Group C is found to be higher than either of the groups and among all the three orbital vessels.

Figure 2: Comparison Of Psv In Orbital Vessels In The Present Study
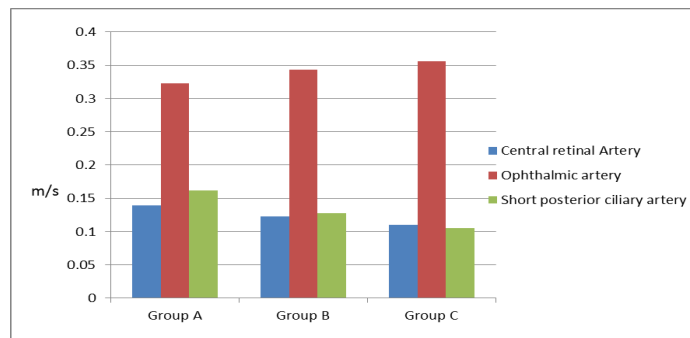
Group A: Control
Group B: Diabetes without Retinopathy Group C: Diabetes with Retinopathy
Fig 2 shows a graphical representation of PSV in each vessel among all three groups. PSV of OA is increased in Group C when compared to Group A & B. In CRA & SPCA the PSV is said to be decreased statistically in Group C when compared to Group A and B.

Table 4: Comparison Of Edv Among The Orbital Vessels In Each Group

Artery	Group A	Group B	Group C
Central Retinal Artery	Aa 0.036±0.001	Ab** 0.029±0.001	Ac** 0.02±0.00
Ophthalmic Artery	B**a 0.089±0.001	B**b** 0.078±0.001	B**c** 0.070±0.0005
Short posterior Ciliary Artery	C**a 0.047±0.001	C**b** 0.035±0.002	C**c** 0.027±0.001

Means bearing same superscript do not differ significantly
Data   : Mean± S.E
Group A : Control
Group B : Diabetes without Retinopathy
Group C : Diabetes with Retinopathy Uppercase superscript   : Comparison within the group Lowercase superscript   : Comparison between the groups
*Signifiant (P ≤ 0.05); ** Signifiant (P ≤ 0.01)*

The above table shows the EDV of all three vessels under each group.

In CRA, the EDV is seen to be significantly reduced in Group B and C when compared to Group A. The EDV is least in Group C which implies that the blood flow velocity is significantly reduced in patients with diabetic retinopathy when compared to the controls.

In OA, the EDV is seen to be significantly reduced in Group B and C when compared to Group A. The EDV is reduced in Group C which implies that the blood flow velocity is minimum in patients with diabetic retinopathy when compared to patients without retinopathy and controls.

In SPCA, there is a decrease in EDV in Group B and C when compared with Group A. It is significantly reduced in Group C which implies that the blood flow velocity is least in the patients with diabetic retinopathy when compared to patients without retinopathy andcontrols.

The above table implies that EDV in all three vessels are reduced when compared to normals and furthermore there is a significant reduction in patients with diabetic retinopathy when compared to patients without retinopathy.

Figure 3: Comparison Of Edv In Orbital Vessels In The Present Study
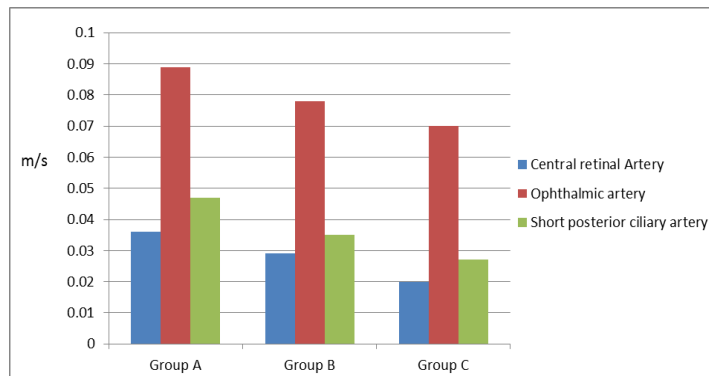
Group A: Control
Group B: Diabetes without Retinopathy Group C: Diabetes with Retinopathy
Fig 3 shows a graphical representation of EDV in each vessel among all three groups.
EDV of all three vessels are reduced.
There is a significant statistical reduction of EDV in Group C when compared to Group A and B of all the orbital vessels.

Table 5: COMPARISON OF RI AMONG THE ORBITAL VESSELS IN EACH GROUP

Artery	Group A	Group B	Group C
Central Retinal Artery	B*a 0.737±0.008	Ab** 0.760±0.006	Ac** 0.816±0.004
Ophthalmic Artery	ABa 0.723±0.002	Ab** 0.772±0.003	B**c** 0.802±0.001
Short Posterior Ciliary Artery	Aa 0.707±0.008	B**a 0.719±0.019	C**a 0.741±0.005

Means bearing same superscript do not differ significantly
Data : Mean± S.E
Group A : Control
Group B : Diabetes without Retinopathy
Group C : Diabetes with Retinopathy Uppercase superscript : Comparison within the group Lowercase superscript : Comparison between the groups
* Signifiant (P ≤ 0.05); ** Signifiant (P ≤ 0.01)
The above table shows the RI of all three vessels under each group.

In CRA, the RI is seen to be significantly increased in Group B and C when compared to Group A. The RI in the patients without diabetic retinopathy was significantly greater than that of normal subjects (P < 0.01). The RI in the patients with diabetic retinopathy (0.816 ± 0.004) was significantly greater (P < 0.01) than that of normal subjects (0.737 ± 0.008) and of patients without diabetic retinopathy (0.760 ± 0.006). Therefore the RI is found to be increased and it is statistically highly significant when compared between the groups.

In OA, the RI is seen to be significantly increasing in Group B and C when compared to Group A. The RI in the patients without diabetic retinopathy was significantly greater than that of normal subjects (P < 0.01). The RI in the patients with diabetic retinopathy (0.802 ± 0.001) was significantly greater (P < 0.01) than that of normal subjects (0.723 ± 0.002) and of patients without diabetic retinopathy (0.772 ± 0.003). Therefore the RI is found to be increased and it is statistically highly significant when compared between the groups.
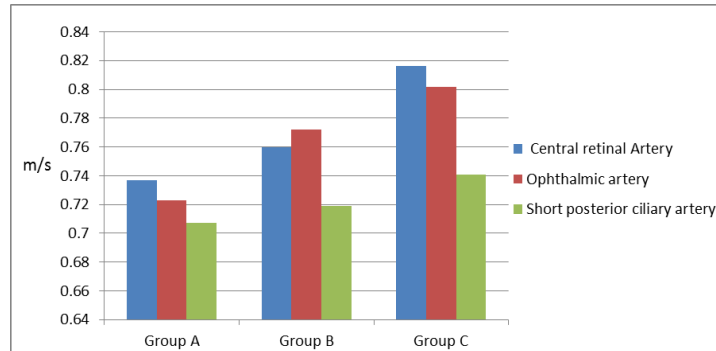
In SPCA, there is no statistical significance between the three groups. Patients with or without diabetic retinopathy have similar values when compared with the normal subjects. The RI of SPCA is statistically significant and varies when compared to RI of OA and CRA.

In Group B the RI of CRA and OA are almost similar within the group but statistically different from SPCA.

In Group C the RI of all three vessels are significantly different from each other.
RI is a good indicator in the progress of diabetic retinopathy in a patient by using CDI.

**Figure 4: COMPARISON OF RI IN ORBITAL VESSELS IN THE PRESENT STUDY**

Group A: Control

Group B: Diabetes without Retinopathy Group C: Diabetes with Retinopathy

Fig 4 shows a graphical representation of RI in each vessel among all three groups.

RI of CRA and OA are found to be increasing. There is a significant statistical increase of RI in Group C when compared to Group A and B of CRA and OA. In SPCA, there is no statistical significance of RI between the three groups.

Figure 5: COMPARISON OF CRA PARAMETERS IN THREE GROUPS
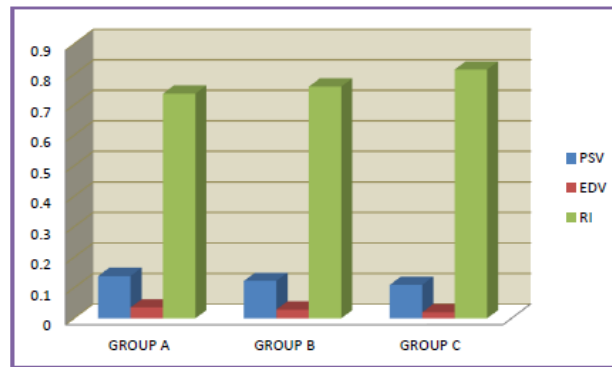
In the above figure, PSV and EDV of CRA is decreased in patients with diabetic retinopathy when compared to the normal subjects and patients without diabetic retinopathy. The RI is increased in patients with diabetic retinopathy when compared to other groups.
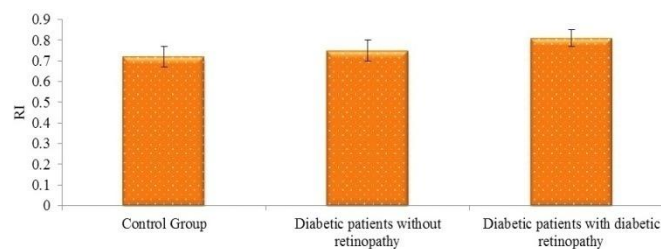
Figure 6: COMPARISON OF PSV IN CRA
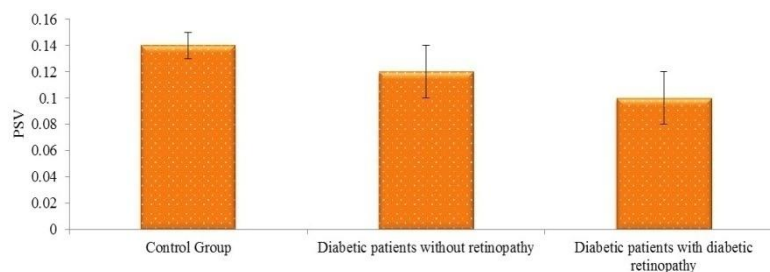
In the above figure there is significant decrease in the PSV of Diabetic Retinopathy patients when compared to the other groups.

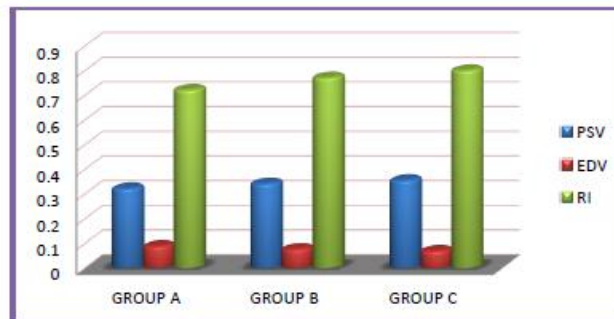**Figure 7: COMPARISON OF EDV IN CRA**
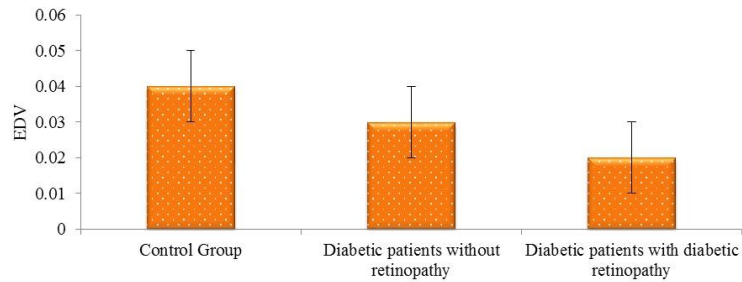
In the above figure there is significant decrease in the EDV of Diabetic Retinopathy patients when compared to the other groups

Figure 8: COMPARISON OF RI IN CRA

In the above figure there is significant increase in the RI of Diabetic Retinopathy patients when compared to the other groups.

Figure 9 : COMPARISON OF OA PARAMETERS IN THREE GROUPS

The above figure depicts the increase in the PSV and RI in diabetic retinopathy patients. There is a decrease in the EDV in diabetic retinopathy cases.

Figure 10: COMPARISON OF SPCA PARAMETERS IN THREE GROUPS
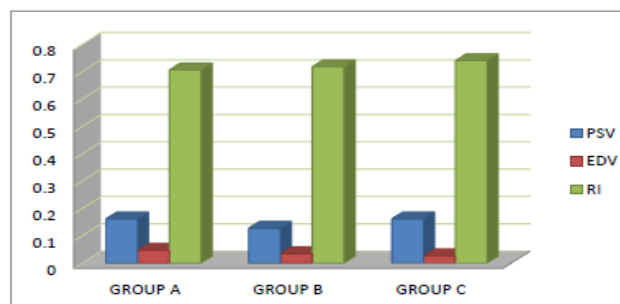
The above figure shows the blood flow velocities in SPCA, there is no significant difference in Group C when compared to the other groups.

Statistical Analysis

Descriptive and inferential statistical analysis has been carried out in the present study.

Analysis of variance (ANOVA) has been used to find the significance of study parameters between three or more groups of patients.

Post-Hoc Duncan test has been used to find the significance. Significant figures:

Group A: Control

Group B: Diabetes without Retinopathy

Group C: Diabetes with Retinopathy Uppercase superscript   : Comparison within the group Lowercase superscript   : Comparison between the groups

* Signifiant (P ≤ 0.05)   - moderately significant

** Signifiant (P ≤ 0.01)   - strongly significant

Statistical software: The Statistical software namely SAS 9.2, SPSS 20.0, Stata 10.1, MedCalc 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**.**

V. Discussion

Colour Doppler Imaging is a new technique for analysing orbital perfusion in pathologic conditions affecting the vascular system. CDI has been applied in a large number of studies that investigated the blood flow parameters of retinal vascular diseases. Most of these studies concerned, the ocular blood circulation in diabetes mellitus. Velocity measurements in OA, CRA, SPCA are rendered possible. CDI is sensitive enough to investigate hemodynamic changes in different grades of diabetic retinopathy.

Using CDI, the RI's of orbital vessels was measured in patients with diabetes mellitus and was found to be significantly greater than those of normal subjects and to be further increased in the presence of diabetic retinopathy. The RI has been used as a measure of vascular resistance in the artery.The value of calculating the Resistive Index (RI) has previously been highlighted by Mulhernet al. (1996), helping to give a more accurate and non-angle dependent measurement.

In the present study, the RI of patients in CRA without diabetic retinopathy was significantly greater than that of normal subjects and further increased with diabetic retinopathy. The PSV and EDV of CRA in diabetic patients, regardless of the presence or absence of retinopathy, were significantly lower than those of the control group. There is a significant difference in the EDV and PSVof CRA noted between the patients with and without diabetic retinopathy. In patients with diabetic retinopathy it is seen that both PSV and EDV are very much reduced and is statistically significant as well. The PSV and EDV of CRA in patients without diabetic retinopathy are increased in comparison to patients with diabetic retinopathy.

 Goebel et al in his study has proved that the RI of SPCA is increased in patients with diabetes when compared to the normal individuals. The RI is increased in patients with and without diabetic retinopathy.

Dimitrova in her work has also found the significant increase of RI in SPCA in patients with and without diabetic retinopathy when compared to the controls.

Mendivil and Cuartero (1996) have reported CDI findings of a mixed group of type I and type II diabetics with PDR after laser photocoagulation. Panretinal photocoagulation resulted in reduction of the PSV in OA when compared to values before laser treatment. This parameter again could not be assessed in the current study as these group of patients undergoing photocoagulation were not included in the study.

In the study conducted by Dimitrova, there was a reduction of blood flow velocity both in NPDR and PDR and the increase in RI was evident in CRA, OA and SPCA. The blood flow velocities in CRA, OA and SPCA decreased after panretinal photocoagulation of diabetic retinopathy.

The finding of the present study that the RI of CRA and OA in patients with and without retinopathy are significantly greater than those of normal individuals is in agreement with certain other studies such asMacKinnon et al. Our findings are in contrast with Grunwald *et al*. who found no differences in blood flow velocity in healthy eyes compared with the eyes of diabetic patients with or without retinopathy.

There are many different results in the literature which relates to the association of blood flow velocities and diabetic retinopathy. The interpretation of data is complicated by the demographic variability of patients, the methodological problems related to the outcome measures in these studies, and their subsequent statistical analyses. The present study is based on the fact that none of the patients with type II diabetes were on treatment for any other systemic conditions. These patients were excluded to focus on the effect of diabetes on orbital blood flow in type II diabetic patients. Great care was taken to apply very little pressure on the patient's eye during colour Doppler Imaging examination.

TABLE 6: Comparison of Blood Flow Velocities in various studies with present study in normal individuals:

	Goebel and coworkers	Galassi and coworkers	Lieband coworkers	Greenfieldand co-workers	AburnAnd Coworkers	GuthoffAnd coworkers	Present Study
Number of eyes	70	40	40	53	50	72	120
CRA PSV	9.4 ± 1.2	13.4 ± 2.4	10.3 ± 2.1	11.0 ± 2.5	10.1 ± 1.9	9.5 ± 3.1	13.9 ± 3.0
CRA EDV	2.4 ± 0.8	2.0 ± 1.8		4.0 ± 1.4	2.6 ± 1.2	3.1 ± 1.6	3.6 ± 1.0
SPCA PSV	11.2 ± 1.9	12.5 ± 3.1	12.4 ± 4.8	10.6 ± 3.5	12.4 ± 4.2		16.2 ± 2.0
SPCA EDV	3.4 ± 1.2	3.1 ± 0.4		4.4 ± 2.1	4.3 ± 2.2		4.7 ± 1.0
OA PSV	35.9 ± 5.1	41.3 ± 3.4	31.4 ± 4.2	37.9 ± 10.8	31.3 ± 4.2	31.6 ± 9.0	32.3 ± 4.0
OA EDV	8.5 ± 2.5	9.5 ± 2.0		10.6 ± 4.3	8.3 ± 3.9	8.2 ± 3.7	8.9 ± 1.5

The primary limitations of the current study includes a single observer for measurement of the Doppler indices to assess the hemodynamic changes, hence the measurement values could vary from user to user or even by the same user over time. Another limitation was the small sample size. Type I Diabetes mellitus patients could have been compared to Type II diabetic patients. Much more specific age group of patients could have been helpful in finding the changes occurring at specific age. We have also ruled out the conditions like glaucoma and hypertension, those with history of smoking and previous history of intraocular surgery which are factors in causing ocular vasculopathy.

VI. Conclusion
❖ Colour Doppler Imaging is a useful modality to assess the risk of developing proliferative diabetic retinopathy which can lead to visual loss.
❖ In CDI there is a significant decrease in blood flow velocity (PSV & EDV) of CRA of diabetic patients and it was further reduced in diabetic patients with retinopathy.
❖ There is a significant decrease in blood flow velocity (PSV & EDV) of SPCA of diabetic patients and it was further reduced in diabetic patients with retinopathy.
❖ In OA, PSV was found to be higher in diabetic patients with retinopathy when compared to the control group. EDV was found to be reduced in patients with diabetic retinopathy when compared to the normal individuals.
❖ In this study there is a significant decrease in the EDV of all three vessels i.e OA, CRA, SPCA in patients with diabetic retinopathy from the control group.
❖ RI is significantly increased in patients with diabetic retinopathy in OA and CRA.
❖ There is no statistical significance in the RI of SPCA between the three groups.
❖ RI of all three orbital vessels are statistically significant from each other.
❖ RI of CRA can be used to assess the progression of diabetic retinopathy in patients or can also be used post panretinal photocoagulation.
❖ It is also found that the RI values in Ophthalmic Artery is increased in diabetic patients.
❖ Even though further investigations are needed to assess orbital blood flow in retinopathy, based on our study the results suggest CDI has the ability to give the information on hemodynamic changes and can be used as a supportive modality for diagnosis of diabetic retinopathy in patients.

VII. Summary
✓ The aim of this study is to evaluate hemodynamic changes of Ophthalmic Artery, Central Retinal Artery and Short Posterior Ciliary Artery in diabetic patients with and without diabetic retinopathy by comparing it with normal individuals.

- ✓ To find the use of Colour Doppler Imaging in differentiating diabetic patients with retinopathy from those without retinopathy.
- ✓ The study was conducted at Meenakshi Medical College Hospital and Research Institute, Kanchipuram. A total of 60 patients were included in this study, divided into three groups each containing 20 patients.
- ✓ Using CDI, blood flow velocities i.e PSV, EDV and RI were found in OA, CRA and SPCA for each of the three groups. In this study, it is found that RI is increased in OA and CRA of patients with diabetic retinopathy and CRA is more sensitive of all the three vessels due to its peripheral vascular supply.
- ✓ PSV of OA is increased in patients with diabetic retinopathy whereas PSV is reduced in CRA and SPCA in patients with diabetic retinopathy.
- ✓ EDV is decreased in all three orbital vessels in patients with diabetic retinopathy.
- ✓ RI is similar between the three groups of SPCA and there is no statistical significance.
- ✓ CDI can be used in evaluating the hemodynamic circulation in orbital vessels and is a useful modality to assess the progression of diabetic retinopathy when other techniques are inaccessible to these vessels. It gives reliable information on blood flow velocities at the sites of complex vasculature.

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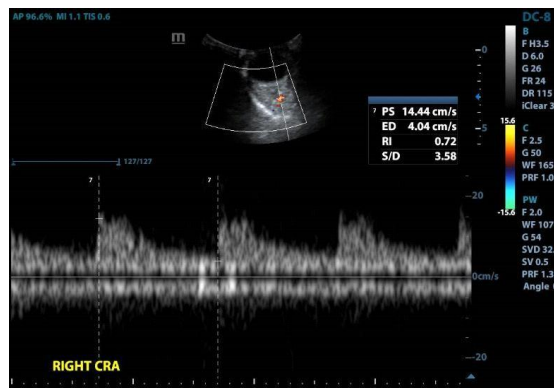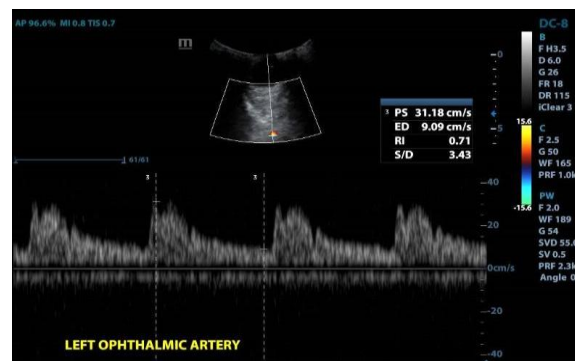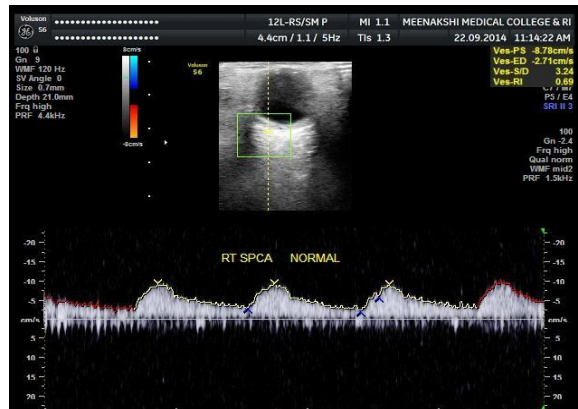
Colour Plate 1:Right Central Retinal Artery In Controls
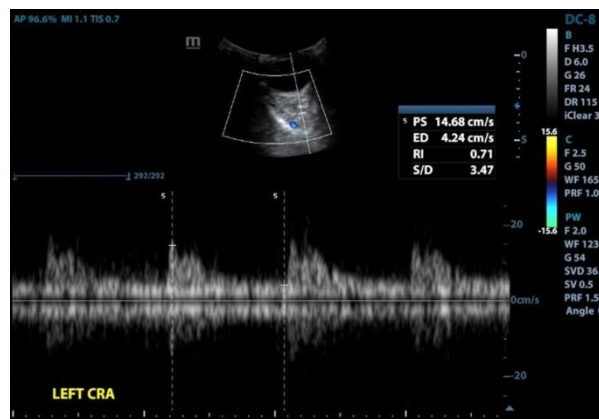
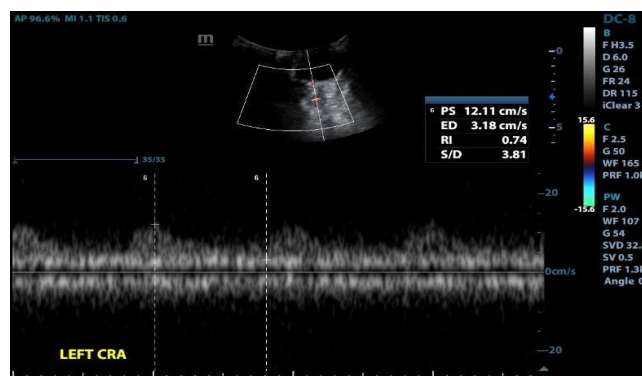

Colour Plate 2: Left Central Retinal Artery In Controls
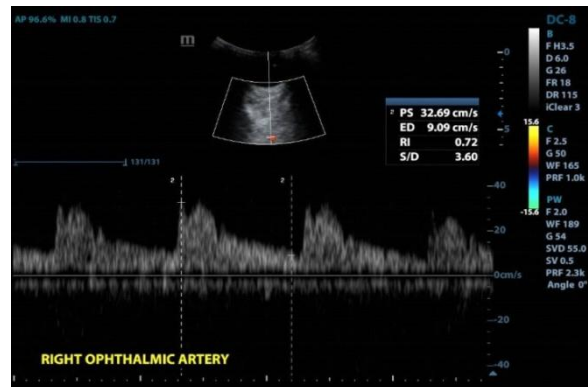
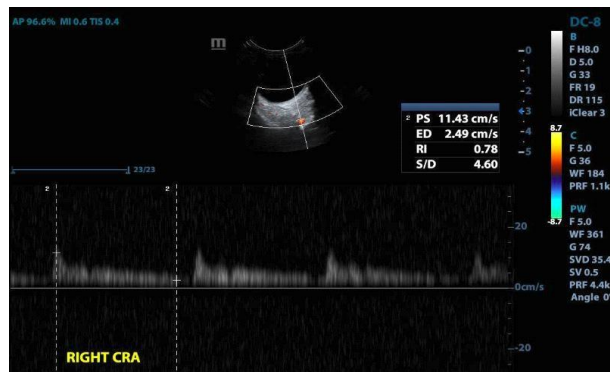**Colour Plate 3: Right Ophthalmic Artery In Controls**

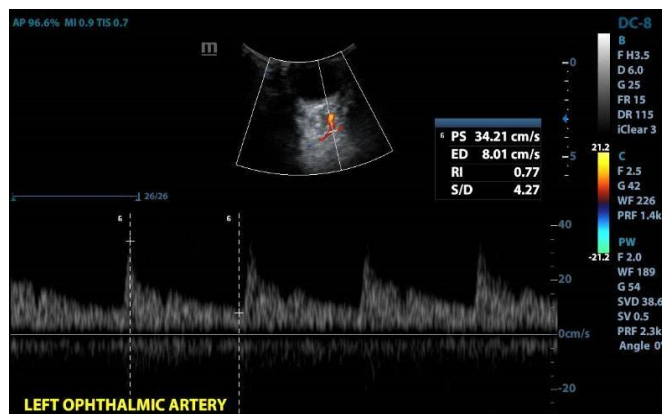**Colour Plate 4: Left Ophthalmic Artery In Controls**

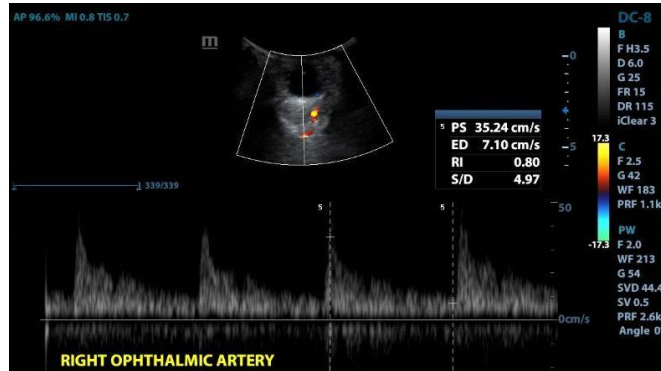**Colour Plate 5: Right Short Posterior Ciliary Artery In Controls**

Colour Plate 6: Left Cra In Patients Without Diabetic Retinopathy
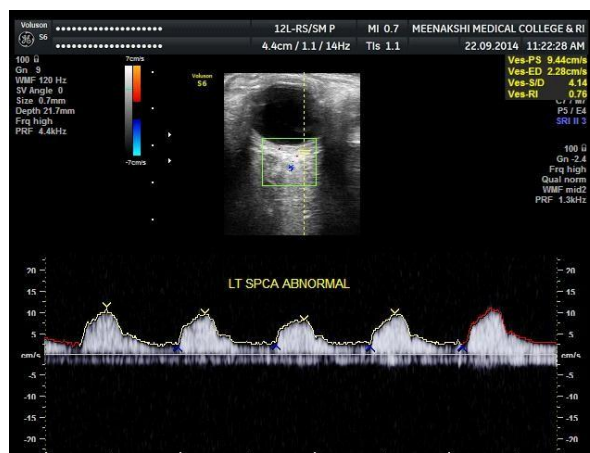

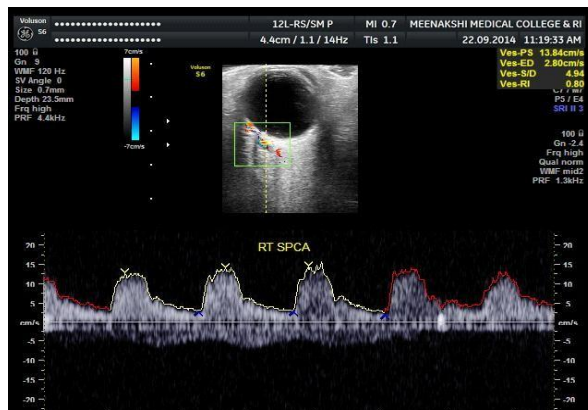**Colour Plate 7: Left Cra In Patients With Diabetic Retinopathy**

Colour Plate 8: Left Oa In Patients Without Diabetic Retinopathy

Colour Plate 9: Right Oa In Patients With Diabetic Retinopathy

Colour Plate 10: Left Spca In Patients Without Diabetic Retinopathy

Colour Plate 11: Right Spca In Patients With Diabetic Retinopathy