Visual Acuity, Intraocular Pressure, and Macular Thickness in Patients Undergoing Dialysis

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Abstract

Background: Chronic kidney disease (CKD) is a public health problem over all the world. CKD may also be defined by the presence of kidney damage or a reduced glomerular filtration rate (GFR), which is the best overall indicator or index of kidney function. CKD patients are usually treated using kidney dialysis (hemodialysis) that uses a blood filtration mechanism (HD). Several metabolic parameters, such as blood urea, sodium, potassium, and glucose levels, can alter during HD. Osmotic alterations in blood, aqueous and vitreous humor, and other extracellular fluids arise from these fluctuations. That also can affect visual acuity, intraocular pressure (IOP), and retinal thickness.
Aim of the Study: To evaluate some of the ocular findings undergoing HD to keep prevent the loss of patient vision such as visual acuity (VA), intraocular pressure (IOP), central corneal thickness (CCT), central Foveal Thickness (CFT), retinal nerve fiber layer (RNFL).
Patient& Methods: This is a cohort (prospective) design study. This study including Seventy nine patients divided into two groups the first group from one week to six month (9 femal & 18 males) another group over than six month (36 female & 16 male) the average age between (12 to 70 years). This research performed in the three places department of the eye in Al-Hussein hospital in Samawah city, Al-Haboby hospital, Al-Hussein hospital in Dhi Qar city finally in Al-Shaheed Gazy hospital and Baghdad teaching hospital in Baghdad. Examining Visual Acuity by Snellen chart & auto refractometer, IOP& CCT by (CT.1 Computerized Tonometer TOPCON), RNLF and Central Foveal Thickness by OCT (Carl ZEISS, TOPCON). The inclusion criteria were as follows: all the patients undergoing dialysis from one week to over six months. Exclusion criteria were as follows: the patients have diabetic, any patients have a hereditary disease or glaucoma history or laser therapy, or intraocular injection in the eye before dialysis, the patients have a problem in the eye before dialysis such as cataracts or opacity leads to does surgery, the patients who have a refractive error or wear glass had been also excluded.
Result: Includes the results of seventy-nine patients (45 females and 34 males) with chronic kidney disease examined ocular findings before a session of dialysis divided into two groups based on their duration of dialysis. Group one with twenty-seven patients (9 female & 18 male) under dialysis from one week to six months with mean & standard deviation (3.2037, ± 1.89259), group tow with fifty tow patients (36 female & 16 male) under dialysis from the duration over than six months with mean & standard deviation (44.2308, ± 26.24367) respectively. Patients aged (12 to 70 years) had mean age & ± standard deviation (35.1481, ± 12.88918), (44.4038, ± 15.42249) for two groups respectively. Patients in two groups had IOP (Right eye), its mean & standard deviation (15, ± 2.34), (15.69, ± 2.56) for group one & group tow respectively. Also, patients had CCT (Right eye) with mean & standard deviation (5.3467E2, ± 39.00296), (5.2312E2, ± 30.44162) for group one & group tow respectively. Patients had CCT (Left) with mean & standard deviation (5.2878E2, ± 37.55748), (5.2179E2, ± 29.58957) for group one & group tow respectively. Patients in two groups had average thickness RNFL (Right eye) with mean & standard deviation (1.0604E2, ± 25.17551), (95.6154, ± 21.27150) for group one & group tow respectively. Also, patients had average thickness RNFL (left eye) with mean & standard deviation (1.0930E2, ±23.80177), (98.7500, ± 23.77334) for group one & group tow respectively.
Conclusions: This study found CCT effective with dialysis tend to be thin (53 patient,18 patient in group one &35 in group two) and that will be had a threefold higher risk of developing glaucoma when compared with thick average because of the IOP value affected by it. Refractive error effective with dialysis & become was more prominent that can be shown in the group two have (40 patient from 52) while (15 patient from27) in the group one although a lot of them corrected to the BCVA. In conclusion high value of the C/D ratio formed about (45.57%, 53.16%) to the right &left eye respectively this value will be form important sign of risk factor to progressive of glaucomatous need to be alert in the future. Also our research reveals CFT effective undergoing dialysis the thick value was (56 in the right eye, 55 in the left eye) high compared with the thin (9 in the right&9 in the left eye) & normal (14 in the right eye, 15 in the left eye). All the two groups of patients will be effected by the duration of dialysis with a time.

Key Words: Intra Ocular Pressure, Central Corneal Thickness, Best Correction Visual Acuity, Retinal Nerve Fiber Layer, Central Foveal Thickness.

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Introduction

HD can have a wide range of effects on CKD patients' eyes. These include Changes in visual acuity, intraocular pressure, retinal thickness, and refraction (Vrabec *et al.*, 2005). Changes were also observed in the ocular surface.

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Corneal, conjunctive, lens, and/or retina pathologies may also develop during the period of HD treatment. Disorders in the retro-bulbar circulation were also recorded after HD (Diaz-Couchoud *et al.*, 2001; Mullaem and Rosner, 2012). End-stage renal disease (ESRD) patients are at risk for developing eye disease.

This risk is linked to ESRD patients' common comorbid conditions, as well as the unique effects of hemodialysis and the uremic state in causing changes in the conjunctivae, cornea, retina, and macula. The most common ocular problems in ESRD patients are red, irritated eyes, which may be related to calcium phosphate product elevations. Band keratopathy may develop in patients with chronically elevated calcium-`phosphate products. Macular edema, ischemic optic neuropathy, elevated intraocular pressure, retinal detachment, and retinal hemorrhage are some of the eye disorders. It is important to consider these conditions as soon as possible that can threaten a patient's vision. This may have been challenging to a nephrologist in a dialysis unit, where a detailed ophthalmological examination is difficult (Mullaem and Rosner, 2012). Many studies have shown significant changes in IOP and central corneal thickness (CCT) for both anterior and posterior segments (Dinc *et al.*, 2010; Sati *et al.*, 2016). Increased IOP and decreased ocular perfusion pressure OPP are the risk factors for the development and progression of glaucoma. An unrecognized significant increase in IOP or OPP reduction during HD may result in optic nerve glaucoma damage and vision loss subsequently (Hu *et al.*, 2013). Given the contradictory reports of HD affecting IOP, precise and mechanistic insights of HD on IOP are not well-established (Song *et al.*, 2006; Levy *et al.*, 2005). If the CCT values are above or below normal, they lead to an incorrect evaluation of IOP values (Erdem and Gunes, 2019).

Patients and Methods

Study Design: This is a cohort (retrospective) design study to investigate the effect of hemodialysis on visual parameters to prevent the progression of loss vision of the patient.

Study Setting: This research performed in the three places department of the eye in Al-Hussein hospital in Samawah city, Al-Haboby hospital, Al-Hussein hospital in Dhi Qar city finally in Al-Shaheed Gazy hospital and Baghdad teaching hospital in Baghdad it's held in January 2020 but stopped because of the political situation of our country and interrupted by Covied-19 then continued in October 2020 the investigation covers all the patient in these hospitals was suitable for our research.

Study Population: Over than two hundred patient's dialysis included in this study but causes of previous conditions we spoke about it made them not committed to coming to the exam, finally, there are seventy-nine patients participated, group-one with twenty-seven patients under dialysis from one week to six months (9 females and 18 males), group-two with fifty tow patients(36 females and 16 males), under dialysis from the duration over than six months all of them their age range between (12 to 70 years).

Study Variables: Chronic Renal Failure is a systemic disease that will effect on the organs & tissues such as the eye making some patients suffering from itching & blurred vision also causes changing in ocular finding, VA, IOP, CCT, RNFL, central foveal thickness are parameters can be affectednesses undergoing dialysis pre or post-session, therefore, investigations done to prevent losing any one of them.

Data Collection: Informed consent to participate in this study was obtained from all of the patients and information include: The name of patients and age. 2- Phone's number, social status, occupation, address. 3- Duration of dialysis for all patients were undergoing three to four-hour HD sessions for two, three days per week, with high-performance dialyzers. 4-Causes of dialysis (hypertension, stone of kidney, increase of urea, and unknown causes). 5-Asking him about history family if there is any hereditary disease, if there is eye disease or if he examine eye and wear glasses or not.

Instruments

- **Chart of Visual Acuity:** It is important to push the patient to read every letter possible on the optotypes being tested (Salmon, 2020).
- **Autorefractometers:** Fundamentally, two types of autorefractors derive objective refraction: image quality analysis and retinoscopy ((Editor), 2017).
- **Non-Contact Tonometry (Air-Puff):** The non-contact tonometer (NCT) was developed by Goldmann in the early 1970s and uses a jet of air to applanate the anterior corneal surface (Medeiros, Brandt and Liu, 2007).

- **Pachymetry:** There are two types of Pachymetry contact and noncontact tonometry in this study we use (Auto Kerato-Refracto-Tonometer [TRK-1P]; Topcon Corporation, Tokyo, Japan) (Al Farhan, 2016).
- **Optical Coherence Tomography:** OCT is fully nonsurgical images without impacting the tissue that is imaged. Quick signal processing and Fast scanning rates and permits for image visualization in real-time and at a video rate. The resolution of OCT is very high than that of other ways medical imaging like ultrasound or magnetic resonance imaging (MRI) (Fujimoto and Swanson, 2016).

Results & Discussion

- **Correlation Groups:** Table 1 revealed a strong significant positive correlation between CCT for the right eye of patients with the CCT for the left eye of patients inside, and a strong significant negative correlation between the CCT for the two eyes of patients with CCT corrected IOP for two eyes of the patients on the other side. Also, there is a significant positive correlation between the CCT for the two eyes of patients with VA for two eyes of patients that have glass. The central foveal thickness for the right eye of patients was a strong significant positive correlation with the central foveal thickness for the left eye of patients, inside and a significant negative correlation with CD ratio for the left eye of patients & CCT corrected IOP for the right eyes of the patients on the other side. Also, the central foveal thickness for the left eye of patients was a strong significant positive correlation with the central foveal thickness for the right eye of patients. There is a strong significant negative correlation between the duration of dialysis & average thickness RNLF for the right eye of the patients inside and a significant negative correlation with average thickness RNLF for the left eye of the patients on the other side. The CCT corrected IOP for two eyes of patients was a strong significant negative correlation with the CCT for two eyes of patients on the side and with VA for the two eyes of patients that have glass on the other side. Also, the CCT corrected IOP for right eyes of patients was a significant negative Correlation with the central foveal thickness for the right eye of patients.

To obtaining accurate IOP measurements, free from the errors Figure 1, Examining the association of CCT with IOP(that corrected depending on correction factor of CCT) we were found a significant association between CCT&IOP in the left eye of patients under dialysis that examined pre-session show when the CCT is decreasing (thin) the IOP will increase and vis versa when it increases (thick) the IOP will decease we found 53 patient total of two groups have thin CCT with mean18.5849 & Std. Deviation ±3.02829 at p=<0.0001, (18 patient in the group one &35 in the group tow) this value refer to risk factor and progression of glaucomatous happen with the time even if the IOP in the average normal now, that agreement in the study of Elias Chelala et al they found a change in IOP correlated significantly with pre-HD serum albumin levels and weight change, in the other side we found 14 patient have the average normal of CCT while 12 patient have thick CCT with mean 13.4167 & Std. Deviation ±1.97523 that also will lead to another problem such as edema. While actually, we found (15 patients, 5 from group one & 10 from group two) have a high value of IOP & two patients (one patient from each group) suffer from low value. ALL the patients examined in the same instrument in three hospitals computerized kerato tonometry which examined CCT&IOP at the same time. Also, The RNLF is very important parameter can also be affected by change happened in the body it's the value reported as high (6 patients in the group one, 5 patients in the group tow), normal (19 patients in the group one, 38 in the group tow, four of them the age was 70 years old) & low (4 in the group one, 9 in the group tow) taking in account the factor of age. Figure 2 reveals there is a significant association between RNLF& duration of dialysis showed the value of the RNLF will decrease with increasing duration of dialysis.

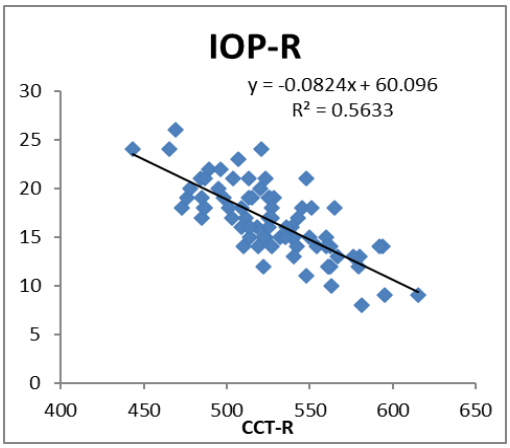
- **The Duration of dialysis Groups:** Numerous metabolic parameters change during dialysis, including blood urea, sodium, potassium, and glucose levels, which also induce osmotic changes in blood and extracellular fluids. This includes changes in the aqueous and vitreous humor, which can result in visual acuity, IOP, CCT, CFT, and C/D ratio

changes. Chelala et all in 2015, Brad Bowling et all in 2016 mentioned in their study that because the pressure chamber was filled with saline solution and connected to a small reservoir that will be affected with an osmotic pressure of the body in another side radius of Central corneal thickness covered the curvature with tear film that also effected with many factors, therefore, must be measured (Erdem and Gunes, 2019). This study examined patient from two weeks to six months & from six months to more than, figure 3 show that:

- **The association between Refractive error & Duration of Dialysis for 6 months versus longer than 6 months:** Table 2 reveals a highly significant association between refractive error & duration of dialysis for 6 months versus longer than 6 months (P<0.0001). This study found 37.5% of patients suffer from hypermetropia, 81.8% suffer from myopia in the group one while in another group we found 62.5% suffer from hypermetropia, 18.2% suffer from myopia that will disagreement with Umut Asli Dinc et al they found non-significant in the refractive error undergoing dialysis, (see figure 4). All previously refers to HD will effect on VA slightly & that will progress with the time. All the patients examined by Snellen chart &the report by decimal also the same instrument auto refractometer (Topcon) in three hospitals.
- **The association between the Duration of dialysis less than or equal to 6 months vs longer & CCT corrected IOP-R level:** Table 3 indicates borderline significant association the Duration of dialysis less than 6mo vs longer & CCT corrected IOP-R level at p = 0.066. In the right eye, we found thin the average value of CCT in the borderline(51 patient, 17 in group one & 34 in group two) while the high average value of IOP was (16 patient, 5 in group one & 11 patient in the group tow), (see figure 5).
- **The CD ratio status for the left eye of patents with CCT, VA with glass, RNFL-L, & CFT-L:** Table 4 indicates significant differences between the central foveal thickness & the CD ratio status for the left eye at p = 0.01, with total mean & standard deviation (2.2980E2, ± 31.76290) respectively. Also shows non-significant differences between the CD ratio status for the left eye & CCT-corrected IOP for the left eye, CCT, VA-with-glass, RNFL for the left eye at p-value >0.05. BI chart (figure 6) reveals that value of C/D ratio classified in three groups of patients the first doesn't have C/D ratio form about (26.58%, 22.76%) to the right &left eye respectively, the second group have average normal (27.85%, 24.05%), the third group has high value of C/D ratio (45.57%, 53.16%) to the right &left eye respectively this value will form the important sign of risk factor to progressive of glaucomatous in the future. All the values of the C/D ratio measured by 3D OCT-1000(Topcon, Tokyo, Japan) & SD-OCT (Carl Zeiss Meditec).

Conclusions

1. This study investigated the changes in ocular and parameters during hemodialysis to identify significant factors & we found CCT effective with dialysis tend to be thin (53 patient, 18 patient in group one &35 in group two) and that will be had a threefold higher risk of developing glaucoma when compared with thick average because of the IOP value affected by it.
2. Refractive error effective with dialysis & become was more prominent that can be shown in the group two have (40 patient from 52) while (15 patient from27) in the group one although a lot of them corrected to the BCVA.
3. In conclusion high value of the C/D ratio formed about (45.57%, 53.16%) to the right &left eye respectively this value will be form important sign of risk factor to progressive of glaucomatous need to be alert in the future.
4. Also our research reveals CFT effective undergoing dialysis the thick value was (56 in the right eye, 55 in the left eye) high compared with the thin (9 in the right & 9 in the left eye) & normal (14 in the right eye, 15 in the left eye).
5. All the two groups of patients will be effected by the duration of dialysis with a time.



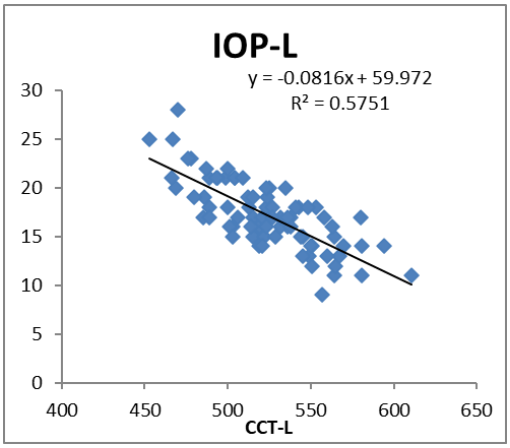
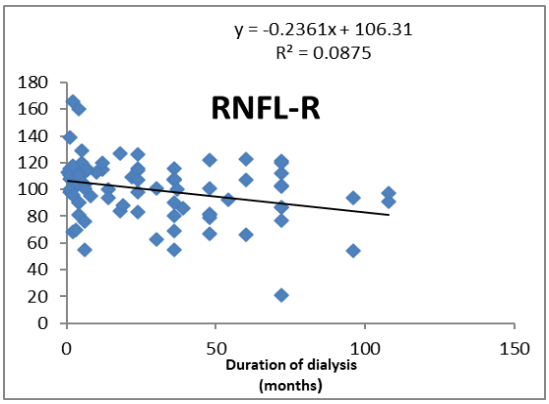


Figure 1. The Linear regression analysis between the IOP versus the CCT for left and right eye



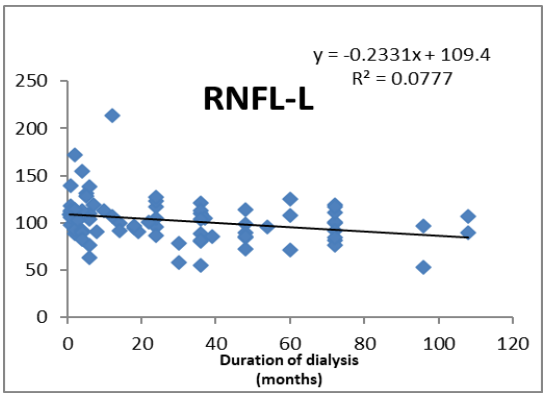
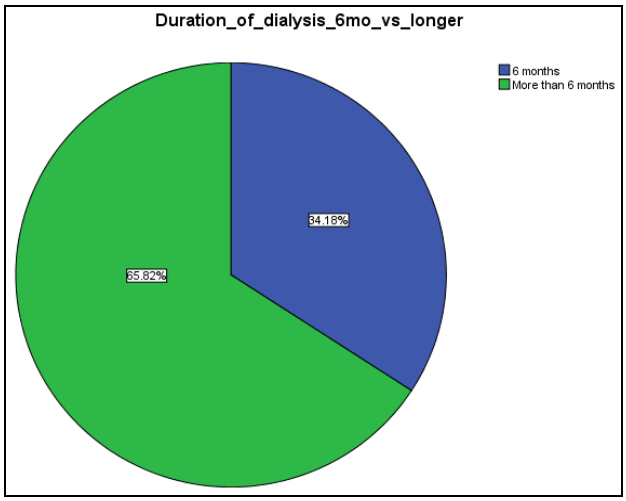
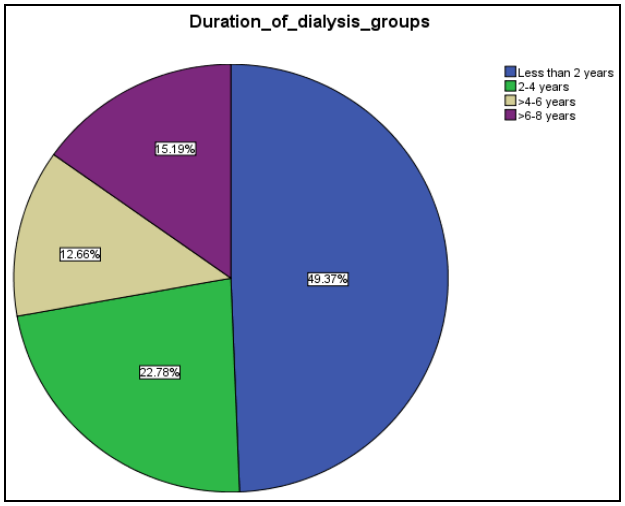


Figure 2. The Linear regression analysis between the RNFL for left and right eye versus the Duration of Dialysis





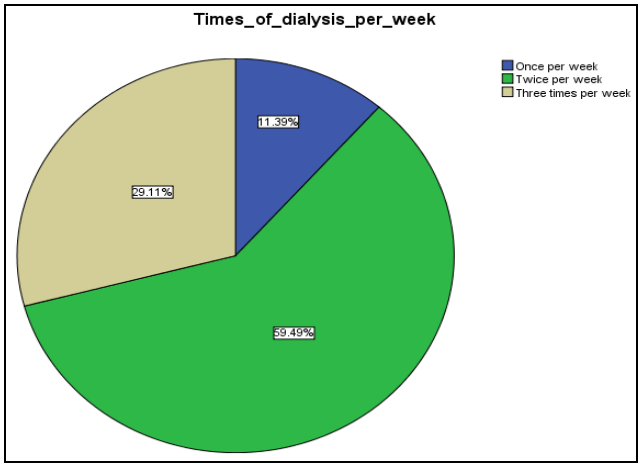


Figure 3. The Duration of dialysis Group

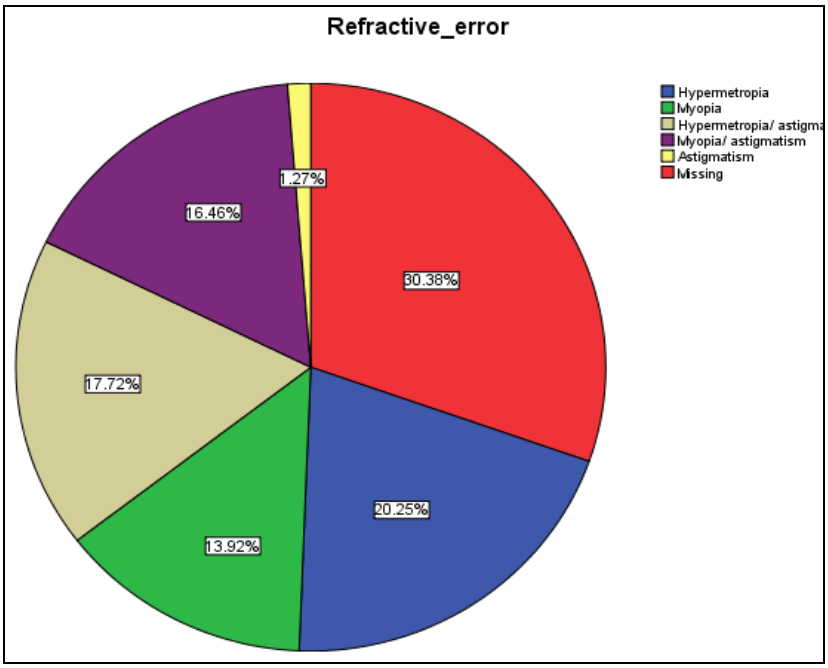
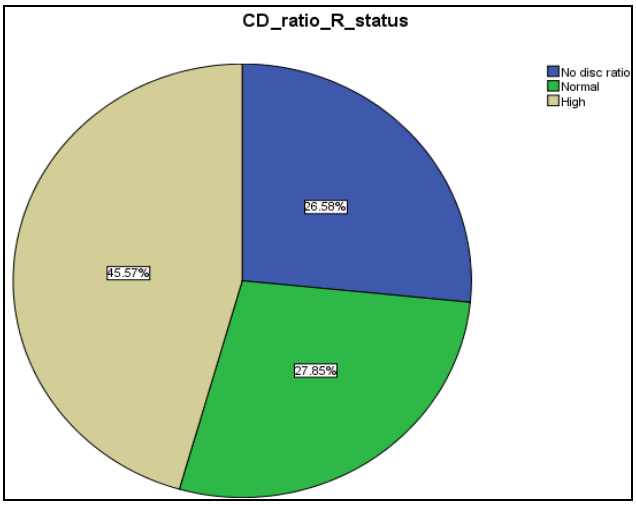


Figure 4: The refractive error of the patients' eyes



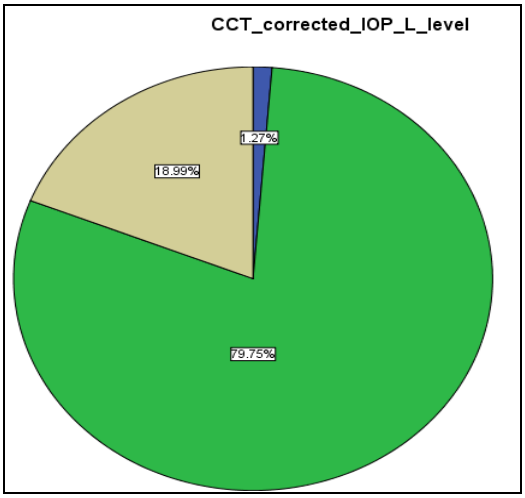
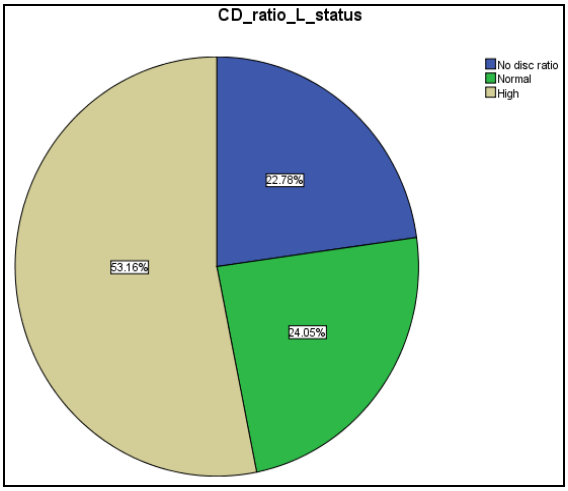


Figure 5. The CCT corrected IOP level for two eyes of patients



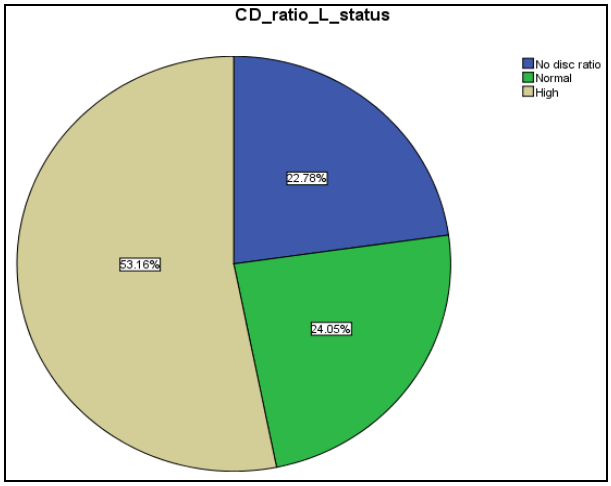


Figure 6. The CD ratio status for two eyes of patients

Table 1. Correlation Groups

Variable		Age	CCT_R	CCT_L	CVT_R	CVT_L	CD_ratio_R	CD_ratio_L	Duration_of_dialysis	CCT_corrected_IOP_R	CCT_corrected_IOP_L	VA_withoutglasses_R	VA_withoutglasses_L	VA_with_G_R	VA_with_G_L	RNFL_R	RNFL_L
Age	Pearson Correlation											-.469**	-.499**		-.436**		
	Sig. (2-tailed)											0	0		0.001		
	N											74	74		52		
CCT_R	Pearson Correlation			.954**						-.751**	-.740**			.294*	.328*		
	Sig. (2-tailed)			0						0	0			0.033	0.017		
	N			79						79	79			53	52		
CCT_L	Pearson Correlation		.954**							-.699**	-.758**			.276*	.283*		
	Sig. (2-tailed)		0							0	0			0.046	0.042		
	N		79							79	79			53	52		
CFT_R	Pearson Correlation					.741**		-.252*		-.233*							
	Sig. (2-tailed)					0		0.025		0.039							
	N					79		79		79							
CFT_L	Pearson Correlation				.741**												
	Sig. (2-tailed)				0												
	N				79												
CD_ratio_R	Pearson Correlation							.777**								-.343**	
	Sig. (2-tailed)							0								0.002	
	N							79								79	
CD_ratio_L	Pearson Correlation				-.252*		.777**									-.284*	
	Sig. (2-tailed)				0.025		0									0.011	
	N				79		79									79	
Duration_of_dialysis	Pearson Correlation															-.296**	-.279*
	Sig. (2-tailed)															0.008	0.013
																79	79
CCT_corrected_IOP_R	Pearson Correlation		-.751**	-.699**	-.233*						.879**			-.467**	-.488**		
	Sig. (2-tailed)		0	0	0.039						0			0	0		
	N		79	79	79						79			53	52		
CCT_corrected_IOP_L	Pearson Correlation		-.740**	-.758**						.879**				-.358**	-.401**		
	Sig. (2-tailed)		0	0						0				0.008	0.003		
	N		79	79						79				53	52		
VA_withoutglasses_R	Pearson Correlation	-.469**											.799**	.651**	.562**		
	Sig. (2-tailed)	0											0	0	0		
	N	74											74	48	48		
VA_withoutglasses_L	Pearson Correlation	-.499**										.799**		.406**	.527**		
	Sig. (2-tailed)	0										0		0.004	0		
	N	74										74		48	48		

VA_with_G_R	Pearson Correlation		.294*	.276*						-.467**	-.358**	.651**	.406**		.755**		
	Sig. (2-tailed)		0.033	0.046						0	0.008	0	0.004		0		
	N		53	53						53	53	48	48		52		
VA_with_G_L	Pearson Correlation	-.436**	.328*	.283*						-.488**	-.401**	.562**	.527**	.755**			
	Sig. (2-tailed)	0.001	0.017	0.042						0	0.003	0	0	0			
	N	52	52	52					52	52	48	48	52				
RNFL_R	Pearson Correlation						-.343**	-.284*	-.296**								.786**
	Sig. (2-tailed)						0.002	0.011	0.008								0
	N						79	79	79								79
RNFL_L	Pearson Correlation								-.279*							.786**	
	Sig. (2-tailed)								0.013							0	
	N								79							79	

*. Correlation is significant at the 0.05 level (2-tailed), **. Correlation is significant at the 0.01 level (2-tailed).

Table 2. The association between the Refractive_error & Duration_of_dialysis_6mo_vs_longer

	P<0.0001		Duration_of_dialysis_6mo_vs_longer		Total
			<=6 months	More than 6-months	
Refractive_error	Hypermetropia	Count	6	10	16
		% within Refractive_error	0.375	0.625	1
		% within Duration_of_dialysis_6mo_vs_longer	0.4	0.25	0.291
	Myopia	Count	9	2	11
		% within Refractive_error	0.818	0.182	1
		% within Duration_of_dialysis_6mo_vs_longer	0.6	0.05	0.2
	Hypermetropia/ astigmatism	Count	0	14	14
		% within Refractive_error	0	1	1
		% within Duration_of_dialysis_6mo_vs_longer	0	0.35	0.255
	Myopia/ astigmatism	Count	0	13	13
		% within Refractive_error	0	1	1
		% within Duration_of_dialysis_6mo_vs_longer	0	0.325	0.236
	Astigmatism	Count	0	1	1
		% within Refractive_error	0	1	1
		% within Duration_of_dialysis_6mo_vs_longer	0	0.025	0.018
Total		Count	15	40	55
		% within Refractive_error	0.273	0.727	1
		% within Duration_of_dialysis_6mo_vs_longer	1	1	1

Table 3. The Duration of dialysis <=6mo vs longer & CCT corrected IOP-R level

	P=0.066		CCT_corrected_IOP_R_level			Total
			Low	Normal	High	
Duration_of_dialysis_<=6mo_vs_longer	6 months	Count	4	20	3	27
		% within Duration_of_dialysis_6mo_vs_longer	0.148	0.741	0.111	1
		% within CCT_corrected_IOP_R_level	0.8	0.328	0.231	0.342
	More than 6 months	Count	1	41	10	52
		% within Duration_of_dialysis_6mo_vs_longer	0.019	0.788	0.192	1
		% within CCT_corrected_IOP_R_level	0.2	0.672	0.769	0.658
Total		Count	5	61	13	79
		% within Duration_of_dialysis_6mo_vs_longer	0.063	0.772	0.165	1
		% within CCT_corrected_IOP_R_level	1	1	1	1

Table 4. The CD ratio status for a left eye of patents with CCT, VA+glass, RNFL-L, & CFT-L.

CD ratio L status		N	Mean	Std. Deviation	P-value
CCT_corrected_IOP_L	No disc ratio	18	17.4444	3.18493	
	Normal	19	17.1579	2.77415	0.94
	High	42	17.0952	3.94974	
	Total	79	17.1899	3.49386	
VA_with_G_L	No disc ratio	11	0.8009	0.2274	
	Normal	12	0.9025	0.12892	0.4
	High	29	0.879	0.19511	
	Total	52	0.8679	0.18959	
RNFL_L	No disc ratio	18	107.56	21.3245	
	Normal	19	104.05	19.5206	0.46
	High	42	99.3571	27.0598	
	Total	79	102.35	24.1603	
CCT_L	No disc ratio	18	513.83	27.8636	
	Normal	19	532	26.0832	0.23
	High	42	525.07	36.1666	
	Total	79	524.18	32.4621	
CFT_L	No disc ratio	18	243.94	25.1875	
	Normal	19	213.16	48.4083	0.01
	High	42	231.26	20.2268	
	Total	79	229.8	31.7629	

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