Original Article

Corneal densitometry in patients with arcus senilis and its correlation with serum lipid levels

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Purpose: To evaluate corneal densitometry (CD) of patients with arcus senilis (AS) and its association with the serum lipid markers. **Methods:** This is a cross-sectional, case-control study. The AS diagnosis was made clinically. Forty-five eyes of 45 patients with AS and 38 eyes of 38 age-matched control subjects with no noticeable AS were enrolled in the study. All participants underwent detailed ophthalmologic examination along with corneal Scheimpflug imaging with CD measurement. The evaluated serum lipid markers of the participants included total cholesterol, triglyceride, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and very-low-density lipoprotein (VLDL). The Spearman correlation analysis was used to correlate the serum lipid values and the CD. $P < 0.05$ was defined as statistically significant. **Results:** The male to female ratio was 26/19 and 14/24 in the study and control groups, respectively ($P = 0.057$). The mean age was 59.56 ± 8.7 and 56.47 ± 8.6 years in the study and control groups, respectively ($P = 0.117$). The mean total CD values in the zones extending from 2 to 12 mm were higher in the study group than in the control group ($P < 0.001$). The serum HDL level was found to be significantly decreased in the study group compared to the control group ($P = 0.048$ and $Z = -1.976$). There was a significant positive correlation between the serum triglyceride level and the CD value of the outermost zone (10–12 mm) ($r = 0.334$ and $P = 0.025$). **Conclusion:** The CD of patients with AS was found to increase not only in the peripheral zone but also in the cornea's paracentral zone compared to the healthy controls. The serum triglyceride level should give an insight into the intensity of arcus senilis. The serum HDL levels were decreased in patients with AS.

Key words: Arcus senilis, corneal densitometry, high-density lipoprotein, low-density lipoprotein, Scheimpflug imaging, triglyceride

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Lipid accumulation within the peripheral corneal stroma circumferentially is called arcus senilis (AS).[1] As the most common peripheral corneal degeneration, the appearance of AS is flat, white, or yellowish and separated from the limbus with a clear zone.[2] The prevalence of AS is reported to increase with advancing age, affecting nearly 80% of individuals older than 60 years of age.[3–5] AS is an indirect sign of abnormal lipid levels, atherosclerosis, and the presence of AS is linked to the increased rate of cardiovascular disease.[5–7]

The accumulated material in AS is composed of cholesterol particles, sized between 40 and 200 nm, and derived from serum triglycerides and low-density lipoprotein.[8] Abnormal lipid deposition is noted in various layers of the cornea, and these depositions have been shown to modify the corneal biomechanics, especially the corneal hysteresis and resistance factors.[9,10] Corneal densitometry (CD) is a popular diagnostic test in recent years. The quantitative evaluation of corneal transparency made it possible to diagnose, severity classification, and progression monitoring of certain corneal disorders.[11–20]

To date, no study quantitatively has evaluated AS and its association between specific serum lipid parameters. In this study, we compared the CD measurements of patients with AS and age-matched control subjects without any evident AS. Additionally, we evaluated the association between the levels of serum lipids and CD values in patients with AS.

Methods

The design of the study

This is a cross-sectional, case-control study conducted with the collaboration of a tertiary care hospital's ophthalmology and internal medicine department. Forty-five eyes of 45 patients with AS and 38 eyes of 38 age-matched control subjects with no noticeable AS were enrolled in the study. The study protocol followed the Declaration of Helsinki's tenets and was approved by the Agri Ibrahim Cecen University, Faculty of Medicine

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Ethics committee. Informed consent was acquired from all participants.

Individuals who came to the Internal Medicine department for a routine check-up and in whom an increased serum lipid profile had been found without any other systemic pathologies were randomly selected for ophthalmic evaluation. AS diagnosis was made clinically by two clinicians (Y.C.Y and S.C.I) with slit-lamp biomicroscopic evaluation. The right eyes were taken into account in patients with bilateral AS. The age-matched subjects in which AS was not observed were included in the control group. An equal number of right and left eyes of the control subjects were randomly selected and taken into consideration. The axial length and spherical equivalents were measured and compared in both groups. The standard exclusion criteria for both groups were the presence of any additional corneal pathologies rather than AS, any history of ocular surgery, trauma or laser treatment, any history of chronic usage of systemic/topical medication or contact lens, the presence of severe dry eye, tobacco usage, any history of usage of lipid-lowering agents, any history of systemic disease rather than hyperlipidemia, and presence of high refractive errors (higher than 3 D of astigmatism, 4 D of hypermetropia, and 6 D of myopia).

All participants underwent detailed ophthalmologic examination along with corneal Scheimpflug imaging by using Pentacam HR (Oculus Optikgerate GmbH, Wetzlar, Germany). The ophthalmologic assessment comprised best-corrected visual acuity (BCVA) evaluation on the Snellen chart, anterior segment examination with slit-lamp biomicroscopy, intraocular pressure (IOP) measurement (Goldmann applanation tonometer), and dilated fundus examination. Corneal topographical imaging was conducted before the dilation of the pupil in all participants at the same time interval of the day to avoid circadian alterations of corneal tissue. CD, anterior and posterior mean keratometry (K_m), anterior and posterior astigmatism, central corneal thickness (CCT), anterior chamber depth (ACD), anterior chamber volume (ACV), anterior chamber angle (ACA), and corneal volume (CV) were measured. The same experienced person acquired all images.

Corneal densitometry imaging

The corneal transparency was quantitatively measured using Scheimpflug imaging. All measurements were taken by the same experienced personnel under the same room illumination conditions at the same time interval of the day (10 A.M2 P.M) and before the other ocular examinations (e.g., applanation tonometry) that warrant ocular surface contact. The automatic release mode was used to avoid operator-induced artifacts. Three consecutive images were acquired, and only the images with good quality were selected for further analysis; the images with low quality were excluded.

The CD was measured using a previously reported technique.[21] The device automatically finds and centers the corneal apex. The degree of backward scattering light of the corneal tissue located within a 12-mm ring centered on the corneal apex was quantitatively measured in grayscale units by the device. The device is capable of dividing the 12-mm ring of the cornea into four zones comprising the central 2-mm diameter circle and the ring-shaped corneal zones that extend between 2–6 mm, 6–10 mm, and 10–12 mm. Additionally, the densitometry of the superficial, central, and deep corneal tissue (the anterior at 120 μm and the central and the most posterior at 60 μm) can be measured in all corneal zones [Figs. 1 and 2]. The topographical (mean anterior and posterior keratometry, anterior and posterior astigmatism) and the anatomical (CCT, ACD, ACV, ACA, and CV) aspects of the cornea and the anterior chamber were also measured using the Pentacam HR in all participants at the same session, and the acquired data were recorded.

Statistical analysis

The statistical analysis was conducted by using the Statistical Package for the Social Sciences (SPSS) software version 22 (SPSS Inc., Chicago, IL, USA). The test in the comparison analysis between the groups was selected according to the distribution of the data. The variables were denoted as means and standard deviation. The comparison of the abnormally distributed data between the groups was analyzed using Mann–Whitney U test. Student *t* test is the test of choice in the comparison of the normally distributed data. Spearman correlation analysis was used to correlate the serum lipid values and the CD. $P < 0.05$ was defined as statistically significant.

For sample size calculation, G*Power (version 3.1) was used. According to the means and standard deviations of two groups in a previous study* (mean1: 14.8, mean2: 13.6; standard deviation1: 1.8, standard deviation2: 1.3), a minimum of 37 patients was needed for 90% power and 95% confidence interval.[22]

Results

Demographic, ophthalmologic, and laboratory data

In total, 83 eyes of 83 participants were included in the study, in which AS was observed in 45 eyes of 45 cases (study group). The control group comprised 38 eyes of 38 patients (control group). The male to female ratio was 26/19 and 14/24 in the study and control groups, respectively ($P = 0.057$). The mean age was 59.56 ± 8.7 and 56.47 ± 8.6 years in the study and control groups, respectively ($P = 0.117$). Both groups were statistically age-matched. The spherical equivalents and the axial length were similar in both groups ($P = 0.754$ and $P = 0.293$, respectively). The mean BCVA was 0.82 ± 0.08 in the study group and 0.81 ± 0.07 in the control group ($P = 0.486$). The mean intraocular pressure was measured as 15.6 ± 1.44 mm Hg and 16 ± 1.32 mm Hg in the study and control groups, respectively ($P = 0.245$). The fundoscopic examination was within the normal limits in both groups.

The evaluated serum lipid markers of the participants included total cholesterol, triglyceride, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and very-low-density lipoprotein (VLDL). Total serum cholesterol was measured as 220.91 ± 34.64 and 220.89 ± 49.89 mg/dL in the study and control groups, respectively ($P = 0.721$ and $Z = -0.357$). The serum triglyceride levels were measured as 218.64 ± 123.37 and 263.45 ± 178.76 mg/dL in the study and control groups, respectively ($P = 0.395$ and $Z = -0.850$). The LDL, HDL, and VLDL levels were measured as 127.91 ± 30.37, 48.47 ± 12.09, and 44.70 ± 24.54 mg/dL in the study group, respectively, and 125.38 ± 38.74, 53.80 ± 13.66, and 53.28 ± 35.55 mg/dL in the control group, respectively. The serum HDL level was found to be significantly decreased in the study group compared to the control group ($P = 0.048$ and $Z = -1.976$). The LDL and VLDL

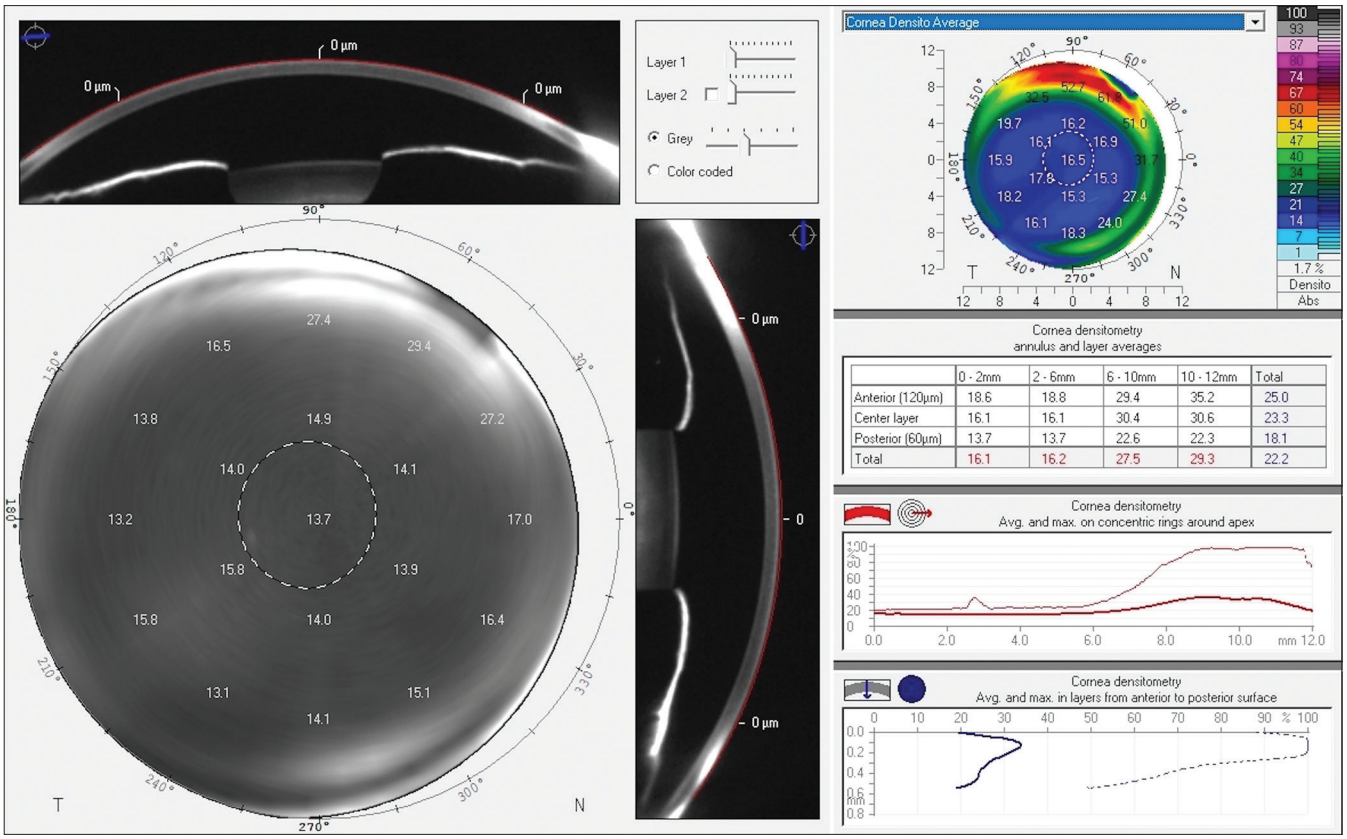

Figure 1: The corneal densitometry measurement of a patient with arcus senilis

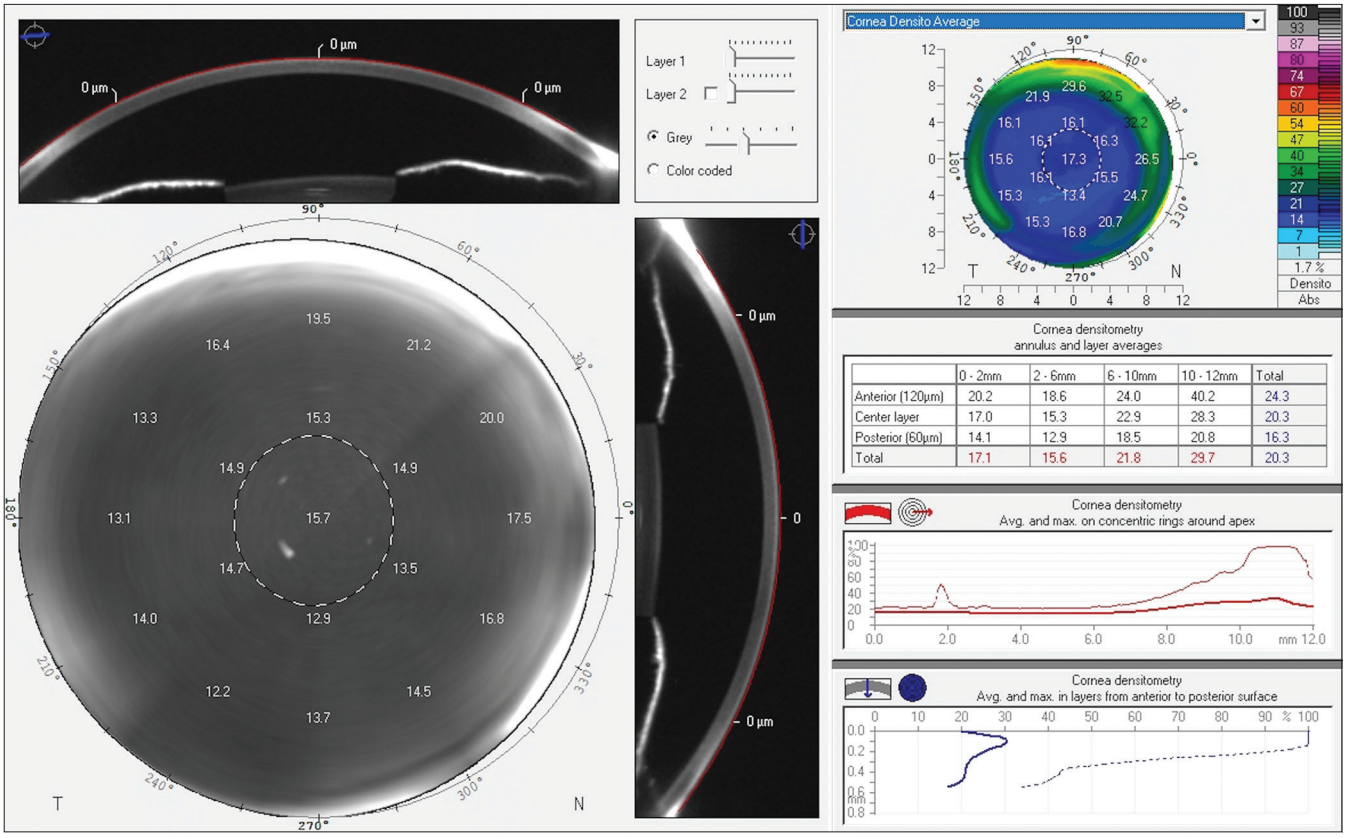

Figure 2: The corneal densitometry measurement of a patient with a healthy subject

Table 1: The descriptive and laboratory values of the groups and the comparison analysis

Group Statistics			
Parameters	**Corneal Arcus State**	**Ratio**	***P***
Gender (M/F)	Absent	14/24	0.057§
	Present	26/19	
Laterality (R/L)	Absent	19/19	0.920§
	Present	22/23	
Parameters	**Corneal Arcus State**	**Mean±SD**	***P* (*Z*-score)**
Age (years)	Absent	56.47±8.6	0.117¶
	Present	59.56±8.7	
Spherical Equivalents (D)	Absent	−0.54±1.1	0.754 (−0.314)¥
	Present	−0.44±1.1	
Axial Length (mm)	Absent	23.56±0.53	0.293¶
	Present	23.68±0.52	
BCVA (Decimals)	Absent	0.81±0.07	0.486¶
	Present	0.82±0.08	
IOP (mm Hg)	Absent	16±1.32	0.245¶
	Present	15.6±1.44	
Total Cholesterol (mg/dL)	Absent	220.89±49.89	0.721 (−0.357)¥
	Present	220.91±34.64	
Triglyceride (mg/dL)	Absent	263.45±178.76	0.395 (−0.850)¥
	Present	218.64±123.37	
LDL (mg/dL)	Absent	125.38±38.74	0.540 (−0.613)¥
	Present	127.91±30.37	
HDL (mg/dL)	Absent	53.80±13.66	0.048* (−1.976)¥
	Present	48.47±12.09	
VLDL (mg/dL)	Absent	53.28±35.55	0.470 (−0.722)¥
	Present	44.70±24.54	

M: Male, F: Female, R: Right, L: Left, D: Diopter, mm: millimeter, BCVA: Best-corrected visual acuity, IOP: Intraocular pressure, mmHg: Millimeter mercury, mg: Milligram, dl: Desiliter, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, VLDL: Very Low-density lipoprotein, SD: Standard deviation. *Statistically significant. §Chi-Square test. ¶Student *t*-test. ¥Mann-Whitney U test

Table 2: Comparison of anterior segment anatomical parameters between the groups

Group Statistics			
Corneal parameters	**Corneal Arcus State**	**Mean±SD**	***P* (*Z*-score)**
Anterior Km (D)	Absent	43.98±1.11	0.257 (−1.134)¥
	Present	43.67±1.24	
Anterior Astigmatism (D)	Absent	0.68±0.42	0.403 (−0.836)¥
	Present	0.81±0.57	
Posterior Km (D)	Absent	6.40±0.18	0.007* (−2.686)¥
	Present	6.27±0.21	
Posterior Astigmatism (D)	Absent	0.22±0.11	0.797 (−0.257)¥
	Present	0.22±0.10	
CCT (µm)	Absent	527.84±25.48	0.042* (−2.030)¥
	Present	514.58±30.54	
ACD (mm)	Absent	2.62±0.20	0.574 (−0.562)¥
	Present	2.73±0.41	
ACV (microL)	Absent	130.45±20.84	0.487 (−0.695)¥
	Present	140.80±40.28	
ACA (degree)	Absent	31.78±6.97	0.898 (−0.128)¥
	Present	31.72±5.85	
CV (mm^3)	Absent	59.48±2.94	<0.001* (−4.082)¥
	Present	56.30±3.27	

K_m: Mean keratometry, D: Diopter, CCT: Central corneal thickness, ACD: Anterior chamber depth, ACV: Anterior chamber volüme, ACA: Anterior chamber angle, CV: Corneal volume, µm: Micrometer, mm: Millimeter, microL: Microliter, SD: Standard deviation. *Statistically significant. ¥Mann-Whitney U test

Table 3: Comparison of corneal optical densitometry between the two groups

Group Statistics			
Corneal Densitometry	Corneal Arcus State	Mean±SD	*P* (*Z*-score)
ACOD (0-2 mm)	Absent	19.10±1.02	0.257 (−1.134)¥
	Present	19.78±3.13	
CCOD (0-2 mm)	Absent	16.21±0.93	0.196 (−1.294)¥
	Present	16.84±2.45	
PCOD (0-2 mm)	Absent	13.32±0.89	0.053 (−1.939)¥
	Present	14.06±1.77	
TCOD (0-2 mm)	Absent	16.21±0.83	0.113 (−1.583)¥
	Present	16.88±2.31	
ACOD (2-6 mm)	Absent	18.29±1.96	0.004* (−2.889)¥
	Present	19.76±4.47	
CCOD (2-6 mm)	Absent	14.97±0.86	0.001* (−3.252)¥
	Present	16.79±3.68	
PCOD (2-6 mm)	Absent	12.47±0.85	0.001* (−3.342)¥
	Present	13.99±2.46	
TCOD (2-6 mm)	Absent	15.15±0.78	<0.001* (-3.507)¥
	Present	16.85±3.45	
ACOD (6-10 mm)	Absent	24.51±4.93	<0.001* (−4.438)¥
	Present	34.47±11.69	
CCOD (6-10 mm)	Absent	22.22±5.15	<0.001* (−4.808)¥
	Present	32.29±10.67	
PCOD (6-10 mm)	Absent	17.97±3.59	<0.001* (−4.484)¥
	Present	24.02±6.72	
TCOD (6-10 mm)	Absent	21.22±4.45	<0.001* (−4.867)¥
	Present	30.19±9.38	
ACOD (10-12 mm)	Absent	35.39±9.47	<0.001* (−3.661)¥
	Present	42.29±9.45	
CCOD (10-12 mm)	Absent	28.23±7.69	<0.001* (−4.278)¥
	Present	33.73±6.44	
PCOD (10-12 mm)	Absent	22.74±5.49	0.002* (−3.053)¥
	Present	26.11±5.38	
TCOD (10-12 mm)	Absent	28.87±7.17	<0.001* (−3.967)¥
	Present	34.04±6.55	

ACOD: Anterior corneal optical densitometry, CCOD: Central corneal optical densitometry, PCOD: Posterior corneal optical densitometry, TCOD: Total corneal optical densitometry, mm: millimeter, SD: Standard deviation. *Statistically significant. ¥Mann-Whitney U test

levels were similar in both groups ($P = 0.540$, $Z = -0.613$ and $P = 0.470$, $Z = -0.722$, respectively) [Table 1].

Measurement of topographical and anterior chamber parameters

The mean anterior K_m and posterior K_m values were 43.67 ± 1.24 and 6.27 ± 0.21, respectively, in the study group, and 43.98 ± 1.11 and 6.40 ± 0.18, respectively, in the control group ($P = 0.257$, $Z = -1.134$ and $P = 0.007$, $Z = -2.686$, respectively, by Mann–Whitney U test). The posterior K_m value was found to be significantly lower in the study group compared to the control group ($P = 0.007$, $Z = -2.686$). The mean anterior corneal astigmatism and posterior corneal astigmatism was 0.81 ± 0.57 and 0.22 ± 0.10, respectively, in the study group and 0.68 ± 0.42 and 0.22 ± 0.11, respectively, in the control group. There was no statistically significant difference in the anterior and posterior corneal astigmatism between the groups ($P = 0.403$, $Z = -0.836$ and $P = 0.797$, $Z = -0.257$, respectively, by Mann–Whitney U test).

The mean central corneal thickness and the CV were found to be significantly lower in the study group compared to the control group (for CCT: 514.58 ± 30.54 vs. 527.84 ± 25.48 µm, respectively, and $P = 0.042$; for CV: 56.30 ± 3.27 vs. 59.48 ± 2.94 mm^3, respectively, and $P < 0.001$). In addition, ACD, ACV, and ACA were similar in both groups ($P = 0.574$, $P = 0.487$, and $P = 0.898$, respectively) [Table 2].

Corneal densitometry measurements and their correlation with the serum lipid values

The mean total CD values in the zones extending from 2 to 6 mm, from 6 to 10 mm, and from 10 to 12 mm were higher in the study group than in the control group ($P < 0.001$, $P < 0.001$, and $P < 0.001$, respectively) [Table 3]. Spearman correlation analysis revealed a significant positive correlation between the serum triglyceride level and the CD value of the outermost zone (10–12 mm) ($r = 0.334$ and $P = 0.025$) [Table 4].

Discussion

AS, as an indirect sign of dyslipidemia and atherosclerosis, is currently diagnosed clinically. Corneal opacities can be evaluated by the CD feature of Scheimpflug imaging as a quantitative method for assessing corneal transparency and has become popular in recent years and adapted to the clinical practice in diagnosing and monitoring various diseases. Our study evaluated the efficacy of CD measurement on the diagnosis of AS by comparing the affected and the normal CD values. Additionally, we analyzed the correlation degree of serum lipid levels with cornea densitometry in AS patients to reveal the most associated serum lipid marker with increased AS density.

The keratometric readings and anterior segment parameters of AS patients have been previously evaluated in various studies. Wu *et al*.[3] assessed the effects of AS on the IOP, keratometry values, and CCT in a population-based study and found significantly thinner CCT and higher IOP in patients with AS. On the contrary, there was no significant difference in the keratometric readings and corneal curvature measurements between the participants with and without AS. In another study, the corneal biomechanical properties were found to decrease in cases with AS compared to the controls. Moreover, there was a significant thickening in the mean CCT of patients with AS compared to the same study's controls. The authors explained the contrary results of their research with the osmotic effect of the accumulated lipid particles in AS.[10] Vurgese *et al*.[4] evaluated the risk factors and various clinical aspects of patients' corneal tissues AS in a cross-sectional study. They showed a significantly thinner CCT and increased cylindrical refractive error in patients with AS compared to the control subjects without AS. There was no significant difference in the keratometric readings, ACD, and IOP between the participants with and without AS. A decrease in CCT with advancing age due to altered collagen density and diminished interstitial substance during life is reported in the literature.[23,24] In addition, AS was reported to be associated with increasing age as well.[3,4] Thus, the decreased CCT might be related to the advanced age rather than the AS itself; therefore, the increased frequency of AS is

Table 4: The correlation analysis between the serum lipid values and the total corneal optical density in patients with arcus senilis

Correlations									
	Total Cholesterol	Triglyceride	LDL	HDL	VLDL	TCOD (0-2 mm)	TCOD (2-6 mm)	TCOD (6-10 mm)	TCOD (10-12 mm)
Spearman's rho									
Total Cholesterol									
Correlation Coefficient									
P									
n									
Triglyceride									
Correlation Coefficient	0.401**								
P	0.006								
n	45								
LDL									
Correlation Coefficient	0.801**	0.347*							
P	<0.001	0.019							
n	45	45							
HDL									
Correlation Coefficient	0.083	-0.217	0.036						
P	0.586	0.152	0.812						
n	45	45	45						
VLDL									
Correlation Coefficient	0.330*	0.794**	0.471**	-0.375*					
P	0.027	<0.001	0.001	0.011					
n	45	45	45	45					
TCOD (0-2 mm)									
Correlation Coefficient	0.142	0.042	0.175	-0.140	0.015				
P	0.351	0.785	0.250	0.360	0.922				
n	45	45	45	45	45				
TCOD (2-6 mm)									
Correlation Coefficient	-0.041	0.106	0.026	-0.009	0.035	0.770**			
P	0.788	0.487	0.867	0.956	0.818	<0.001			
n	45	45	45	45	45	45			
TCOD (6-10 mm)									
Correlation Coefficient	0.077	0.218	0.033	0.021	0.080	0.427**	0.770**		
P	0.617	0.151	0.828	0.893	0.603	0.003	<0.001		
n	45	45	45	45	45	45	45		
TCOD (10-12 mm)									
Correlation Coefficient	0.124	0.334*	0.186	-0.082	0.284	0.305*	0.472**	0.742**	
P	0.416	0.025	0.222	0.593	0.059	0.042	0.001	<0.001	
n	45	45	45	45	45	45	45	45	

**Correlation is significant at the 0.01 level. *Correlation is significant at the 0.05 level. LDL: Low-density lipoprotein, HDL: High-density lipoprotein, VLDL: Very Low-density lipoprotein, TCOD: Total corneal optical densitometry, mm: Millimeter

evident in the older population as well. Our study evaluated whether there was a significant difference in keratometric readings and anterior segment anatomical features between patients with and without AS. We found a statistically significant decrease in posterior K_m, CCT, and CV of patients with AS compared to the age-matched controls. The ACD, ACV, ACA, IOP, spherical equivalent, axial length, and anterior-posterior astigmatism were similar in both groups. Our results support the earlier findings on CCT of patients with AS. Posterior K_m is a valuable parameter in anticipating the postoperative residual astigmatism of patients undergoing cataract surgery.[25] Thus, according to our results, we think that any residual astigmatism is less likely to be observed in patients with AS after cataract surgery.

CD as an indirect measurement of corneal transparency was previously reported as an indicator of corneal health. There is ample published research on CD's efficacy in early diagnosis

or monitoring of various disorders, such as Fabry disease, Fuchs Uveitis, and keratoconus.[11,13,15,16,20] To date, there is no published report on the CD evaluation of patients with AS and its associated serum lipid markers. Increased CD, especially in the outermost corneal zone of the patients with AS compared to the healthy controls, would likely be presumable due to the increased propensity of AS formation in the peripheral cornea. Our study's vital point is not solely dependent on revealing the increased corneal optical density of patients with AS compared to the age-matched healthy controls. We also evaluated the associated lipid levels with the intensity of AS. We found a significantly increased corneal optical density in the cornea's outermost zone with AS and in the paracentral zones, contrary to expectations. This finding shows us that AS is a degenerative process that would likely extend from the peripheral cornea to the paracentral zone.

In correlation analysis, we found a statistically significant positive correlation between CD's intensity in the outermost zone and serum triglyceride levels of patients with AS. However, we found a significantly decreased HDL serum level in patients with AS than in the controls in the comparative analysis. Based on these results, it is logical to think that the decreased HDL, which works as a scavenger lipoprotein that transports the excess cholesterol from peripheral tissues to the liver, should be suspected in the process of AS formation. Previous population-based studies showed conflicting results about the association of serum lipid levels and the prevalence of AS. Wu *et al*.[3] found a significant association between AS prevalence and high total cholesterol levels. However, they did not specifically evaluate the subgroups of serum cholesterol in their study. In contrary to this report and ours, Vurgese *et al*.[4] did not find a significant difference in total cholesterol and HDL levels between the subjects with and without AS. Thus, it is difficult to come to a conclusion with these conflicting results.

There are some limitations of our study. First, the number of subjects enrolled in the study was relatively small. The additional factors that would be associated with the formation of AS were not evaluated. In addition, due to the cross-sectional nature of the study, we did not assess the cumulative effect of various factors on AS formation. We think that it would be possible to follow up on the severity of atherosclerotic status of these cases by using CD soon. More prospective studies with more participants are warranted to research CD's role in monitoring these individuals' well-being status. To do that, more longitudinal studies comprising patients with coronary vascular disease are needed to reveal the association of the cardiovascular risk degree and the AS density.

Conclusion

To conclude, we found a significantly thinner CCT, lower posterior K_m, and lower CV in patients with AS compared to healthy controls. This would be related to the increased prevalence of AS in the older population group in which CCT would likely be thinner due to age-related alterations. The CD of patients with AS was found to increase not only in the peripheral zone but also in the cornea's paracentral zone compared to the healthy controls. The serum triglyceride levels were positively correlated with the intensity of CD of the peripheral zone. The serum HDL levels were lower in patients with AS compared to the control subjects.

Authors' contributions

Y.C.Y, S.C.I and T.C performed the data collection, M.D.O, S.C.I and Y.C.Y planned the work, designed the figures and tables, conducted the statistical analysis, and wrote the paper.

Data availability

The data supporting our findings can be found at Agri State Hospital, Ophthalmology Department.

Consent to participate

All procedures performed were in accordance with the 1964 Helsinki declaration and the institutional ethical standards. The consent for participation from all participants was acquired for the study.

Consent to publish

Written informed consent for publication was obtained from all of the participants.

Ethics approval

The Agri Ibrahim Cecen University, Faculty of Medicine, Ethics Board has approved the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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