

# Correlation and Comparison of Anterior and Posterior Corneal Surface Parameters in Healthy Eyes

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## ABSTRACT

**Purpose:** To correlate and compare anterior and posterior corneal surface parameters like  $K_{\text{flat}}$ ,  $K_{\text{steep}}$ ,  $K_{\text{avg}}$ ,  $R_1$ ,  $R_2$ ,  $R_{\text{avg}}$  and astigmatism in healthy eyes.

**Study Design:** Descriptive correlational study.

**Place and Duration of Study:** This study was conducted At Mayo Hospital, Lahore from June 2020 to Dec. 2020.

**Methods:** This study included 176 subjects (86 males and 90 females) with mean age of  $28.06 \pm 9.68$  and  $28.13 \pm 8.24$  respectively. The data was collected through non-random convenient sampling technique by self-made proforma after taking patients' consent. Anterior and posterior corneal parameters ( $K_{\text{flat}}$ ,  $K_{\text{steep}}$ ,  $K_{\text{avg}}$ ,  $R_1$ ,  $R_2$ ,  $R_{\text{avg}}$  and astigmatism) were measured with GALILEI G4. Pearson correlation test was used for correlation and independent sample t-test/Mann-Whitney U test was used for comparing means of anterior and posterior corneal parameters. Data was entered and analyzed in SPSS-21.

**Results:** Mean of anterior and posterior corneal curvatures was  $44.21 \pm 1.01$  D and  $-6.22 \pm 0.19$  D [ $p < 0.001$ ],  $K_{\text{flat}}$  was  $43.76 \pm 0.99$  D and  $-6.08 \pm 0.19$  D [ $p < 0.001$ ] and  $K_{\text{steep}}$  was  $44.66 \pm 1.08$  D,  $-6.34 \pm 0.21$  D, respectively [ $p < 0.001$ ]. The anterior and posterior corneal curvature  $R_{\text{avg}}$  was  $7.63 \pm 0.17$  mm,  $6.44 \pm 0.200$  mm [ $p < 0.001$ ], mean  $R_1$  was  $7.71 \pm 0.17$  mm,  $6.58 \pm 0.21$  mm, [ $p < 0.001$ ] and mean  $R_2$  was  $7.56 \pm 0.18$  mm,  $6.31 \pm 0.21$  mm, respectively [ $p < 0.001$ ]. Anterior posterior corneal astigmatism was  $0.90 \pm 0.55$  D and  $-0.25 \pm 0.11$  D, respectively [ $p < 0.001$ ]. Anterior corneal parameters also show strong correlation with posterior corneal parameters.

**Conclusion:** There is significant difference between corneal parameters of anterior and posterior surface. Strong correlation was also found in anterior and posterior corneal parameters except corneal astigmatism.

**Key Words:** Cornea, Corneal curvature, Corneal astigmatism, Corneal topography.

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## INTRODUCTION

Cornea which is an avascular tissue acts as a structural barrier and protects the eye from outer insults.<sup>1</sup> Anterior refractive surface of the eye is also provided by pre-corneal tear film. The contribution of cornea in refractive power is about two third.<sup>2</sup> It is the most sensitive and highly innervated tissue in the body.<sup>3,4</sup> It measures 9 to 11 mm vertically and 11 to 12 mm horizontally. In males and females, the corneal average

diameter is  $11.77 \pm 0.37$ mm and  $11.64 \pm 0.47$ mm, respectively.<sup>5,6</sup>

Cornea has different power in various meridians which results in astigmatism. Importance of corneal refractive power is that it is used in calculation of power of intraocular lens and in refractive surgeries.<sup>7</sup> Non-contact devices like Pentacam and Galilei G4 make three dimension images of corneal anterior section, mark corneal topography and pachymetry. Pentacam utilizes a rotating Scheimpflug camera to make topographical images of anterior segment, a twofold Scheimpflug camera and a Placido topographical framework. Likewise, there are different instruments used for corneal curvature measurements; Orbscan, Javal-Schiottz keratometer, Verion Optical Imaging System etc.<sup>8-10</sup> These parameters and their correlation are important in accurate measurement of different intraocular lens implants.<sup>11,12</sup> Finding out concordance among different topographic and tomographic instruments is important in clinical practice.<sup>13,14</sup>

Current study deals with measuring corneal parameters of both anterior and posterior corneal surface. This study finds the correlation and comparison of corneal parameters of both sides of cornea, which will be helpful in understanding the effect of change of anterior or posterior corneal parameters on each other.

## METHODS

This cross-sectional study was conducted at outdoor of eye department of Mayo Hospital and College of Ophthalmology and Allied Vision Sciences. Non probability convenient sampling method was used. The study period was from June 2020 to December 2020 during which 176 eyes of 88 normal individuals were studied. There were 44 males and 44 females. Data was collected through self-made proforma after taking patients' consent. Following parameters were studied;  $K_{flat}$ ,  $K_{steep}$ ,  $K_{avg}$ ,  $R_1$ ,  $R_2$ ,  $R_{avg}$  and astigmatism. Galilei G4 was used for all these readings. Healthy individuals between 11 to 60 years of age, myopic, hyperopic or emmetrope males and females were recruited for study.

For coorelation between anterior and posterior corneal parameters Pearson's correlation test was applied. Pearson value greater than 0.7 was considered

as excellent correlation. Quantitative variables like Age,  $K_{flat}$ ,  $K_{steep}$ ,  $K_{avg}$ ,  $R_1$ ,  $R_2$ ,  $R_{avg}$  and astigmatism were presented with mean and standard deviation. Independent sample t-test / Mann-Whitney U test were applied for comparing means of corneal parameters. P-value less than 0.05 was considered significant. Data was entered and analyzed by using SPSS-21. Graphs were also made by using SPSS-21 software. For tabulation, Microsoft Excel-16 was used. The research protocol was approved by the Ethical Review Board of College of Ophthalmology and Allied Vision Sciences.

## RESULTS

Anterior mean K showed strong negative correlation with posterior mean K and posterior mean R (-0.78). Anterior flat K showed strong negative correlation with posterior flat K (-0.75). Anterior steep K showed strong negative correlation with posterior steep K (-0.75). Anterior mean R showed strong positive correlation with posterior mean R (0.78). Anterior  $R_1$  showed strong positive correlation with posterior  $R_1$  (0.76). Anterior  $R_2$  showed strong and positive correlation with posterior  $R_2$  (0.76). Anterior astigmatism showed poor but negative correlation with posterior astigmatism (-0.33) (Table 2).

Anterior and posterior corneal curvature mean K was  $44.21 \pm 1.01$  D and  $-6.22 \pm 0.19$  D, respectively with  $p < 0.001$ . Anterior and posterior corneal curvature  $K_{flat}$  was  $43.76 \pm 0.99$  D and  $-6.08 \pm 0.18$  D, respectively with a difference of 49.84 D was noted ( $p < 0.001$ ). Anterior and posterior corneal curvature mean  $R_{avg}$  was  $7.64 \pm 0.17$  mm and  $6.44 \pm 0.200$  mm, respectively with a difference of 1.19 mm was noted ( $p < 0.001$ ). The mean  $R_1$  of anterior and posterior corneal curvature was  $7.72 \pm 0.17$  mm and  $6.58 \pm 0.202$  mm, respectively with a difference of 1.13 mm was noted ( $p < 0.001$ ). Likewise, anterior and posterior corneal curvature mean  $R_2$  was  $7.56 \pm 0.18$  mm and  $6.31 \pm 0.211$  mm, respectively. The difference of 1.24 mm was noted ( $p < 0.001$ ). The steep k of anterior and posterior corneal curvature was  $44.67 \pm 1.09$  D and  $-6.34 \pm 0.21$  D, respectively and a difference of 51.01 D was noted ( $p < 0.001$ ). The astigmatism of anterior and posterior corneal curvature was  $0.91 \pm 0.55$  D and  $-0.26 \pm 0.11$  D, respectively and a difference of 1.17 D was noted ( $p < 0.001$ ) (Table 3).

**Table 1:** Age Gender Distribution.

Descriptive Statistics						
Gender		N	Minimum	Maximum	Mean	Std. Deviation
Age	Male	172	11	54	28.06	9.653
	Female	180	11	50	28.13	8.215

**Table 2:** Table of Correlation.

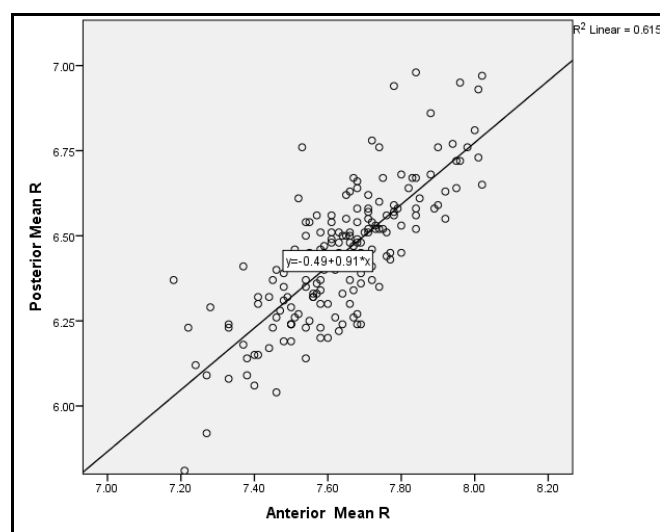
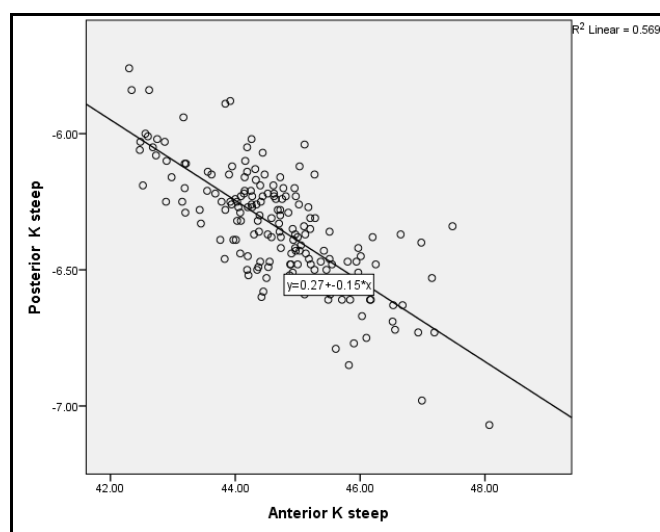
Correlations	Post_K	Post_Flt	Pst_Stp	Post_R	Post_R1	Post_R2	Post_Ast
Sim_K	-.778**	-.773**	-.757**	-.784**	-.775**	-.755**	-0.126
Ant_Flat	-.741**	-.754**	-.702**	-.747**	-.757**	-.700**	-0.036
Ant_Stp	-.756**	-.736**	-.754**	-.761**	-.737**	-.753**	-.199**
Ant_R	.778**	.774**	.757**	.784**	.776**	.756**	0.123
Ant_R1	.743**	.756**	.702**	.749**	.758**	.701**	0.034
Ant_R2	.758**	.738**	.756**	.764**	.739**	.756**	.198**
Ant_Ast	-.148*	-0.085	-.218**	-0.148	-0.082	-.219**	-.328**

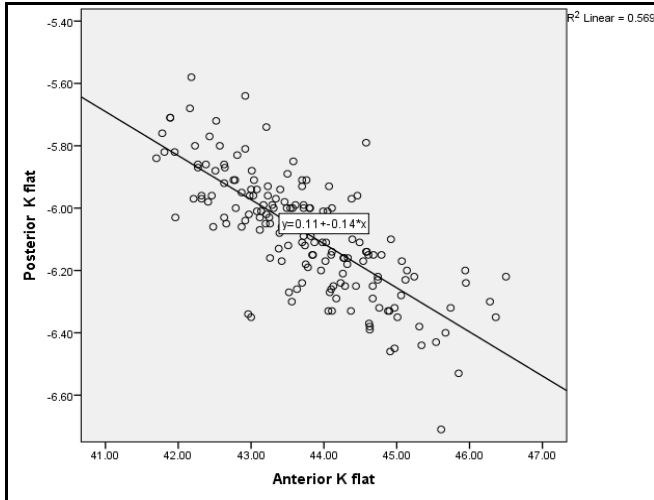
\*\* . Correlation is significant at the 0.01 level (2-tailed).

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

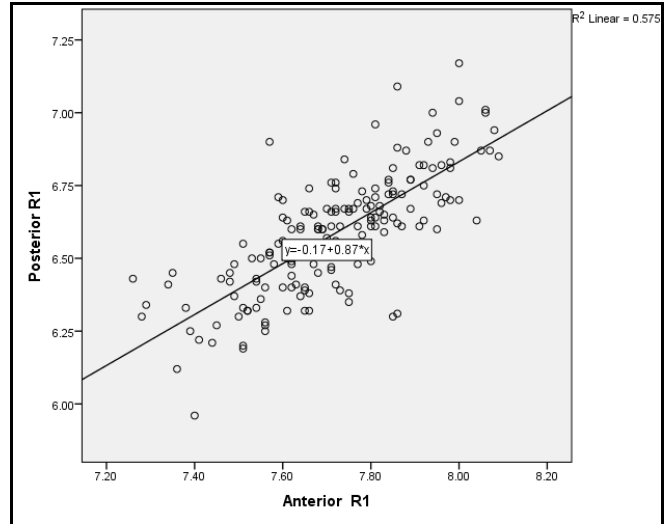
**Table 3:** Table of Comparison.

Category		Mean	Std. Deviation	Std. Error Mean	Mean Diff.	P value
Mean K (D)	Anterior	44.21	1.01	0.08	50.43	< 0.001
	Posterior	-6.22	0.19	0.01		
Flat K (D)	Anterior	43.76	0.99	0.08	49.84	< 0.001
	Posterior	-6.08	0.18	0.01		
Mean R (mm)	Anterior	7.64	0.17	0.01	1.19	< 0.001
	Posterior	6.45	0.21	0.02		
R1 (mm)	Anterior	7.72	0.17	0.01	1.13	< 0.001
	Posterior	6.58	0.20	0.02		
R2 (mm)	Anterior	7.56	0.18	0.01	1.24	< 0.001
	Posterior	6.31	0.21	0.02		
Steep K (D)	Anterior	44.67	1.09	0.08	51.01	< 0.001
	Posterior	-6.34	0.21	0.02		
Astigmatism (D)	Anterior	0.91	0.55	0.04	1.17	< 0.001
	Posterior	-0.26	0.11	0.01		

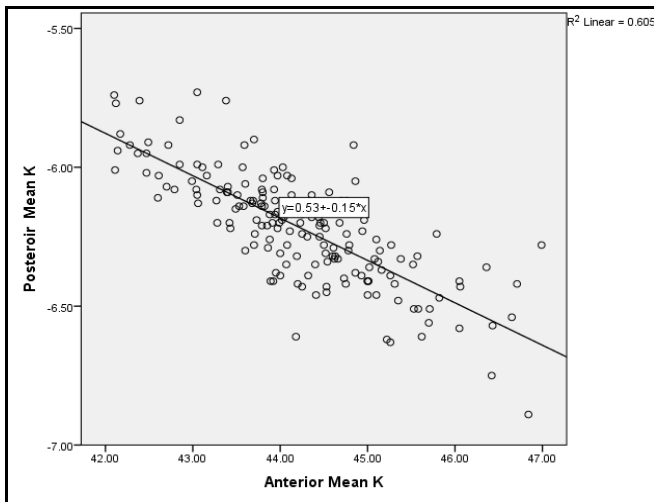
**Figure 1:** Scatter chart of anterior and posterior mean R ( $R^2$ : 0.615).**Figure 2:** Scatter chart of anterior and posterior mean  $K_{steep}$  ( $R^2$ : 0.569).



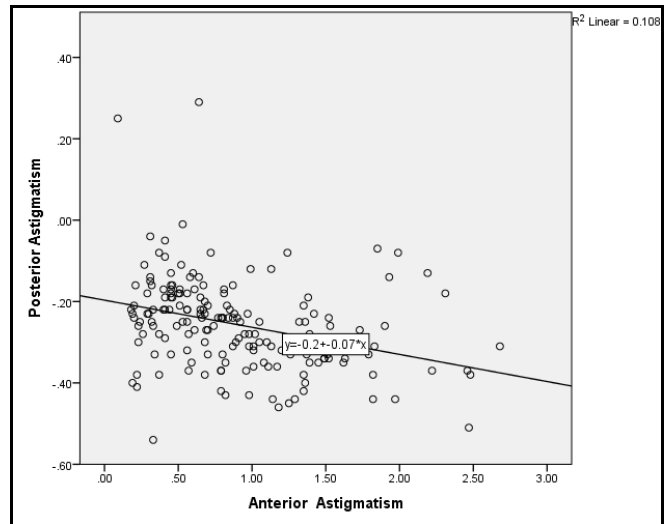
**Figure 3:** Scatter chart of anterior and posterior mean  $K_{flat}$  ( $R^2$ : 0.569).



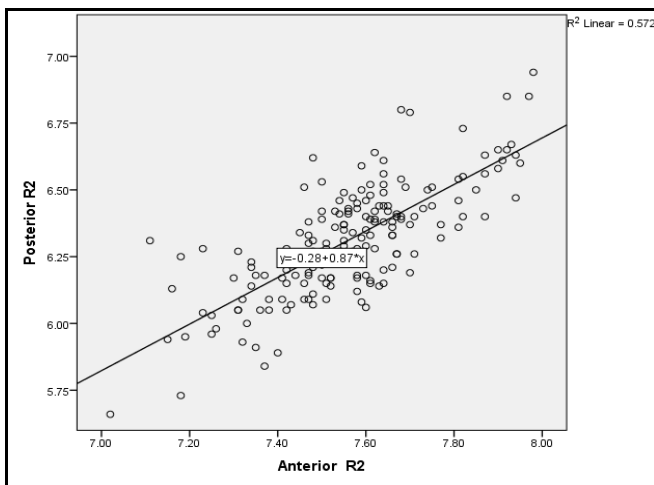
**Figure 6:** Scatter chart of anterior and posterior mean  $R_1$  ( $R^2$ : 0.575).



**Figure 4:** Scatter chart of anterior and posterior mean  $K$  ( $R^2$ : 0.605).



**Figure 7:** Scatter chart of anterior and posterior mean Astigmatism ( $R^2$ : 0.108).



**Figure 5:** Scatter chart of anterior and posterior mean  $R_2$  ( $R^2$ : 0.572).

## DISCUSSION

With the advancement in medical sciences, proper preoperative evaluation of refractive surgeries has improved the surgical outcomes. Imaging techniques in the field of ophthalmology played a key role for such purposes. Corneal imaging techniques provide more precise information. Raul Montalban et al. conducted a study to correlate anterior and posterior corneal radius of curvature which showed correlation coefficient value of 0.86.<sup>15</sup> Raúl Montalbán et al. also found significant difference between anterior and posterior corneal surface in healthy subjects whereas, non-significant difference was found in patients with

Keratoconus.<sup>16</sup> Faik Orucoglu et al. also found similar results.<sup>17</sup> In another study, comparison of anterior and posterior corneal parameters were analyzed in five hundred and fifteen healthy subjects. The study found an average flat K of anterior and posterior corneal surface as  $43.03 \pm 1.57$  D and  $-6.13 \pm 0.26$  D respectively, whereas  $K_{\text{steep}}$  was  $44.17 \pm 1.58$  D and  $-6.41 \pm 0.28$  D respectively.<sup>18</sup> Gender and age related changes of cornea were studied by another group of authors, which showed similar results.<sup>19</sup>

The Gullstrand eye model measured anterior radius of corneas as 7.8mm while 6.5 mm of posterior surface. By using the method of Purkinje image, the  $R_{\text{avg}}$  was 6.42 mm. Eom Eom Y et al measured the astigmatism of anterior surface as 2.21 D and posterior corneal surface as 0.43 D.<sup>20</sup> Yuta Ueno et al. found a shift of against the rule astigmatism from with the rule with age.<sup>21</sup> This study also showed similar results.

Limitations of this study are that we did not compare the results of different age groups. Similarly comparison among different refractive errors was not made. We included normal eyes in our study. Further research can be done by comparing with the eyes with corneal ectasia.

## CONCLUSION

Significant difference was found in anterior and posterior corneal parameters like  $K_{\text{flat}}$ ,  $K_{\text{steep}}$ ,  $K_{\text{avg}}$ ,  $R_1$ ,  $R_2$ ,  $R_{\text{avg}}$  and astigmatism in healthy cornea. A strong negative correlation was found between  $K_{\text{flat}}$ ,  $K_{\text{steep}}$ , and  $K_{\text{avg}}$  of anterior and posterior corneal surface. Whereas, a strong positive correlation was found in  $R_1$ ,  $R_2$ ,  $R_{\text{avg}}$  of anterior and posterior corneal surface. Astigmatism showed poor but negative correlation.

**Conflict of Interest:** Authors declared no conflict of interest.

## Ethical Approval

The study was approved by the Institutional review board/Ethical review board (COAVS/1061/22).

## REFERENCES

1. **Del Monte DW, Kim T.** Anatomy and physiology of the cornea. *J Cataract Refract Surg.* 2011; **37** (3): 588-598. Doi:10.1016/j.jcrs.2010.12.037.
2. **Shaheen BS, Bakir M, Jain S.** Corneal nerves in health and disease. *Surv Ophthalmol.* 2014; **59** (3): 263-285. 10.1016/j.survophthal.2013.09.002.
3. **Sridhar MS.** Anatomy of cornea and ocular surface. *Indian J Ophthalmol.* 2018; **66** (2): 190. Doi: 10.4103/ijo.IJO\_646\_17.
4. **Eghrari AO, Riazuddin SA, Gottsch JD.** Overview of the cornea: structure, function, and development. *Progress Molecular Biology and Translational Science,* 2015; **134**: 7-23. Doi: 10.1016/bs.pmbts.2015.04.001.
5. **Rüfer F, Schröder A, Erb C.** White-to-white corneal diameter: normal values in healthy humans obtained with the Orbscan II topography system. *Cornea,* 2005; **24** (3): 259-261. Doi: 10.1097/01.icc.0000148312.01805.53.
6. **Ghezzi CE, Rnjak-Kovacina J, Kaplan DL.** Corneal tissue engineering: recent advances and future perspectives. *Tissue Engineering Part B: Reviews,* 2015; **21** (3): 278-287. Doi: 10.1089/ten.TEB.2014.0397.
7. **Qian Y, Liu Y, Zhou X, Naidu RK.** Comparison of corneal power and astigmatism between simulated keratometry, true net power, and total corneal refractive power before and after SMILE surgery. *J Ophthalmol.* 2017; **2017**. Doi: 10.1155/2017/9659481.
8. **Leyland M.** Validation of Orbscan II posterior corneal curvature measurement for intraocular lens power calculation. *Eye (Lond).* 2004; **18** (4): 357-360. Doi: 10.1038/sj.eye.6700659.
9. **Wang L, Mahmoud AM, Anderson BL, Koch DD, Roberts CJ.** Total corneal power estimation: ray tracing method versus gaussian optics formula. *Invest Ophthalmol Vis Sci.* 2011; **52** (3): 1716-1722. Doi: 10.1167/iovs.09-4982.
10. **Lauschke JL, Lawless M, Sutton G, Roberts TV, Hodge C.** Assessment of corneal curvature using verion optical imaging system: a comparative study. *Clin Exp Ophthalmol.* 2016; **44** (5): 369-376. Doi: 10.1111/ceo.12687.
11. **Zhang B, Ma J-X, Liu D-Y, Guo C-R, Du Y-H, Guo X-J, et al.** Effects of posterior corneal astigmatism on the accuracy of AcrySof toric intraocular lens astigmatism correction. *Intern J Ophthalmol.* 2016; **9** (9): 1276.10.18240/ijo.2016.09.07
12. **Hua Y, Xu Z, Qiu W, Wu Q.** Precision (repeatability and reproducibility) and agreement of corneal power measurements obtained by Topcon KR-1W and iTrace. *PLoS One,* 2016; **11** (1):e0147086. Doi: 10.1371/journal.pone.0147086
13. **Menassa N, Kaufmann C, Goggin M, Job OM, Bachmann LM, Thiel MA.** Comparison and reproducibility of corneal thickness and curvature readings obtained by the Galilei and the Orbscan II analysis systems. *J Cataract Refract Surg.* 2008; **34** (10): 1742-1747. Doi: 10.1016/j.jcrs.2008.06.024

14. **Shirayama M, Wang L, Weikert MP, Koch DD.** Comparison of corneal powers obtained from 4 different devices. *Am J Ophthalmol.* 2009; **148** (4): 528-535. e1. Doi: 10.1016/j.ajo.2009.04.028
15. **Montalbán R, Piñero DP, Javaloy J, Alió JL.** Scheimpflug photography-based clinical characterization of the correlation of the corneal shape between the anterior and posterior corneal surfaces in the normal human eye. *J Cataract Refract Surg.* 2012; **38** (11): 1925-1933.
16. **Montalbán R, Alio JL, Javaloy J, Piñero DP.** Comparative analysis of the relationship between anterior and posterior corneal shape analyzed by Scheimpflug photography in normal and keratoconus eyes. *Graefes Arch Clin Exp Ophthalmol.* 2013; **251** (6): 1547-1555. Doi: 10.1007/s00417-013-2261-3
17. **Orucoglu F, Toker E.** Comparative analysis of anterior segment parameters in normal and keratoconus eyes generated by scheimpflug tomography. *J Ophthalmol.* 2015; 2015. DOI: 10.1155/2015/925414.
18. **Orucoglu F, Akman M, Onal S.** Analysis of age, refractive error and gender related changes of the cornea and the anterior segment of the eye with Scheimpflug imaging. *Contact Lens and Anterior Eye,* 2015; **38** (5): 345-350. Doi: 10.1016/j.clae.2015.03.009.
19. **Nemeth G, Berta A, Lipecz A, Hassan Z, Szalai E, Modis Jr L.** Evaluation of posterior astigmatism measured with Scheimpflug imaging. *Cornea,* 2014; **33** (11): 1214-1218. Doi: 10.1097/ICO.0000000000000238.
20. **Eom Y, Rhim JW, Kang S-Y, Kim S-W, Song JS, Kim HM.** Toric intraocular lens calculations using ratio of anterior to posterior corneal cylinder power. *Am J Ophthalmol.* 2015; **160** (4): 717-724. Doi: 10.1016/j.ajo.2015.07.011.
21. **Ueno Y, Hiraoka T, Beheregaray S, Miyazaki M, Ito M, Oshika T.** Age-related changes in anterior, posterior, and total corneal astigmatism. *Journal of Refractive Surgery,* 2014; **30** (3): 192-197. Doi: 10.3928/1081597X-20140218-01.

### Authors' Designation and Contribution

Muhammad Suhail Sarwar; Professor: *Concepts, Design, Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing.*

Muhammad Arslan Ashraf; Diagnostic Oculist: *Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing, Manuscript review.*

Faisal Mehmood; Consultant Ophthalmologist: *Literature search, Manuscript preparation, Manuscript editing, Manuscript review.*

Muhammad Arbab Azeem; Diagnostic Oculist: *Literature search, Data acquisition, Manuscript preparation.*

Sobia Yousaf; House Officer: *Manuscript editing, Manuscript review.*

