

# Bicentral, retrospective Study to compare corneal Diameter, Curvature and Eccentricity of Caucasian Eyes



## Introduction:

Novel measurement devices are able to measure the dimensions of the eye with the highest accuracy. Therefore, it is possible to realize a high number of correlations between the detected parameters. Different correlations are important for various fields of optometric developments such as cornea related investigations and the design of contact lenses. The most common type of today's fitted lenses are soft contact lenses. [1] However, soft replacement contact lenses are fitted by the rule "one-size-fits-all" regardless of the real relations between the corneal diameter and the corneal radii. It has to be discussed whether this strategy leads to an appropriate treatment with soft contact lenses for the majority of soft contact lens wearers. Additionally, it is possible to analyze whether the corneal diameter implies a conclusion to the size of the corneal radii.

## Purpose:

The aim of this study is to review the following hypotheses:

- 1) The larger the corneal diameter the flatter the corneal curvature.
- 2) The larger the curvature of the eye the higher the eccentricity.

Furthermore, the relationship between the corneal parameters which are important for soft contact lens fitting will be examined. Therefore, it is important to know in what range the majority of the data are located.

## Methods:

In this retrospective study 5,827 data from right (52%) and left (48%) Caucasian eyes were analyzed. These data were exclusively taken from a topographer (*Keratograph 4*, OCULUS Optikgeräte GmbH) and were collected in two different locations (*Ernst-Abbe-University of Applied Sciences* (n=1,688) and *Optometrie Schwarz* (n=4,139) in Germany. The analyzed data were collected from July 1999 to March 2012. 66% females and 34% males with a mean age of [33.8 ± 14.2] years were included. Eyes with a corneal diameter under 10.00mm and over 13.00mm were excluded. Data from subjects under the age of two as well as data from eyes with irregular astigmatism or corneal deviation from normal results and dysplasia such as keratoconus, keratoglobus, cornea plana were excluded. Furthermore, measured data collected after contact lens wearing (<24h) and of subjects after corneal refractive surgery were excluded. The determination of standard distribution was analyzed by *Kolmogorov-Smirnov test*. Standard distribution was assumed if the mean value was equal to the median of the sample. The correlations between the corneal diameter and the flat and steep radii of corneal curvature as well as the radii of corneal curvature and corneal eccentricity at 30° were analyzed with *Pearson coefficient*. Furthermore, the data were analyzed within the following groups: sex, age, eye order.

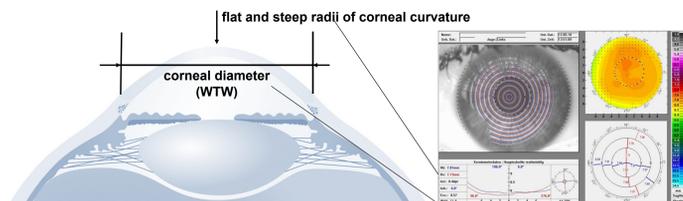


Fig. 1: Measurement of the cornea, screenshot (*Keratograph 4*, OCULUS)

## Results:

### The corneal diameter

The mean corneal diameter is [11.74 ± 0.40]mm. The steepest investigated corneal diameter is 10.03mm and the flattest is 13.0mm. This mean corneal diameter 11.74mm is compared with the mean corneal diameter 11.79mm by *Matsuda et al.* [2] However, the difference of 0.05mm between the two mean corneal diameters is clinically irrelevant. The median of the corneal diameter is 11.73mm. Due to the mean diameter of 11.74mm the standard distribution is assumed. No differences are indicated between right and the left eyes.

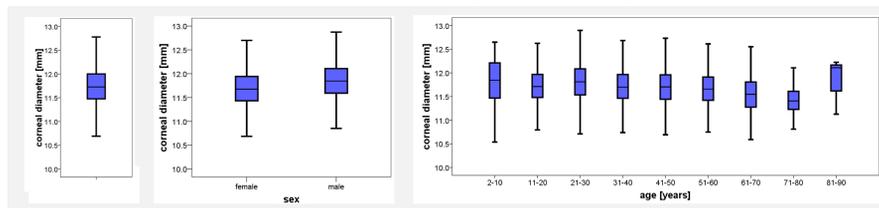


Fig. 2: Corneal radius of curvature [mm] (overall [11.74 ± 0.40]mm); sex (female [11.68 ± 0.38]mm, n=3,788; male [11.85 ± 0.40]mm, n=1,926); age [years] (2-10 [11.82 ± 0.50]mm, n=64; 11-20 [11.72 ± 0.38]mm, n=709; 21-30 [11.81 ± 0.40]mm, n=2,232; 31-40 [11.71 ± 0.38]mm, n=1,119; 41-50 [11.70 ± 0.38]mm, n=913; 51-60 [11.67 ± 0.39]mm, n=509; 61-70 [11.54 ± 0.42]mm, n=191; 71-80 [11.46 ± 0.42]mm, n=87; 81-90 [11.81 ± 0.60]mm, n=3)

### The radius of curvature

#### Steep radius of curvature

Tab.1: Measurement results of the steep radius of corneal curvature [mm], n = 5,827

	All	Female	Male	OD	OS
Mean value	7.67	7.63	7.76	7.68	7.66
Standard distribution	± 0.27	± 0.16	± 0.27	± 0.28	± 0.27
Minimum	6.79	6.79	6.93	6.79	6.80
Maximum	9.28	8.66	9.28	9.28	8.86

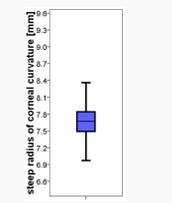


Fig. 3: Boxplot of the steep radius of corneal curvature [7.67 ± 0.27]mm

#### Flat radius of curvature

Tab.2: Measurement results of the flat radius of corneal curvature [mm], n = 5,827

	All	Female	Male	OD	OS
Mean value	7.86	7.82	7.94	7.87	7.85
Standard distribution	± 0.28	± 0.27	± 0.28	± 0.28	± 0.28
Minimum	7.01	7.01	7.06	7.02	7.01
Maximum	9.32	8.83	9.32	9.32	9.21

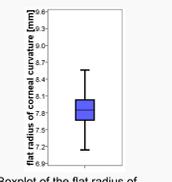


Fig. 4: Boxplot of the flat radius of corneal curvature [7.86 ± 0.28]mm

### The corneal eccentricity at 30°

Tab.3: Measurement results of the corneal eccentricity at 30° (overall, inferior, nasal, superior and temporal), n = 5,827

	All	Female	Male	OD	OS
Overall	Mean value 0.54	0.53	0.54	0.53	0.54
	Standard distribution ± 0.12	± 0.12	± 0.12	± 0.12	± 0.13
Inferior	Mean value 0.51	0.50	0.52	0.52	0.50
	Standard distribution ± 0.22	± 0.22	± 0.21	± 0.21	± 0.23
Nasal	Mean value 0.61	0.62	0.60	0.61	0.61
	Standard distribution ± 0.16	± 0.16	± 0.16	± 0.15	± 0.16
Superior	Mean value 0.55	0.55	0.56	0.54	0.56
	Standard distribution ± 0.17	± 0.17	± 0.16	± 0.16	± 0.17
Temporal	Mean value 0.47	0.46	0.48	0.46	0.48
	Standard distribution ± 0.12	± 0.12	± 0.12	± 0.12	± 0.12

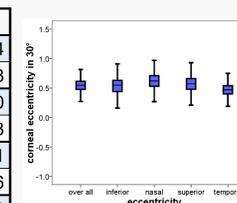


Fig. 5: Boxplot of the corneal eccentricity overall [0.54 ± 0.12]; inferior [0.51 ± 0.22]; nasal [0.61 ± 0.16]; superior [0.55 ± 0.17]; temporal [0.47 ± 0.12]

A correlation ( $r = 0.470$ ;  $R^2 = 0.221$ ;  $p=0.000$ ;  $r = 0.477$ ;  $R^2 = 0.228$ ;  $p=0.000$ ) between the corneal diameter, flat and steep corneal radius of curvature is determined. The results within the groups sex, age and eye order ( $p>0.005$ ) are equivalent.

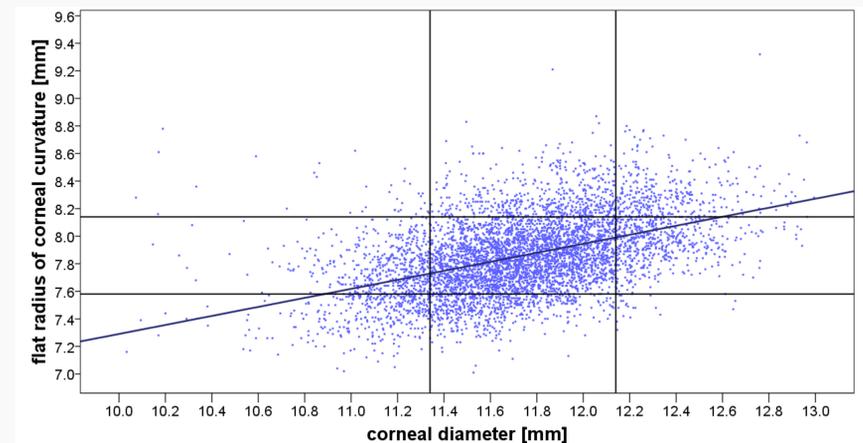


Fig. 6: Correlation between the corneal diameter [mm] and the flat radius of curvature [mm] ( $r=0.470$ ;  $R^2 = 0.221$ ) with the regression line (flat radius of curvature = 0.027 corneal diameter + 4.018), boundaries: mean value ± standard distribution (corneal diameter 11.34; 12.14]mm; flat radius of curvature [7.58; 8.14]mm)

51.2% of all analyzed data are located in the range of [11.34; 12.14]mm (mean ± standard distribution) on the x-axis (corneal diameter) and [7.58; 8.14]mm on the y-axis (flat corneal radius of curvature).

The correlation between the flat and steep radius of curvature and the overall eccentricity at 30° is  $r = 0.125$ ;  $R^2 = 0.016$ ;  $p=0.000$  and  $r = 0.092$ ;  $R^2 = 0.008$ ;  $p=0.000$ .

## Conclusion:

The evaluation of the data shows a positive linear correlation between the corneal diameter and radii of corneal curvature. The hypothesis the larger the corneal diameter the flatter the corneal curvature, is proven and confirmed. Eyes with a flatter radius of curvature tend to have a higher eccentricity at 30°. These conclusions cannot be implemented in common contact lens fitting due to the fact that there is only a small range of contact lens geometries.

"One-size-fits-all" soft contact lens geometries should be designed for diameters from 11.4mm to 12.2mm and radii from 7.58mm to 8.14mm. Soft contact lenses with two base curves should also have two different diameters; the steep base curve a slightly smaller diameter than the flat base curve.

## References:

- [1] GfK: market share CL Germany 2012
- [2] Marsuda LM, W.C., Kame RT, Hayashida JK., Clinical comparison of corneal diameter and curvature in Asian eyes with those of Caucasian eyes. *OVS*, 1992.6 (1): p. 51-54

## Acknowledgements:

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