A Guide to Interpreting Corneal Tomography

Consider using a systematic approach for reading and interpreting corneal tomography.

BY MAZEN SINJAB, MD, PHD

Early in our careers, we learn that corneal tomography is an integral part of measuring corneal curvature and some other features of the cornea. It also has clinical relevance for determining patients' quality of vision. Understanding how this diagnostic tool works and deciphering the information it provides will reduce the likelihood of misdiagnosing corneal ectatic diseases, especially in their early stages, or missing key risk factors for these diseases. I have found that the best way to interpret corneal tomography is by using a four-step, systematic approach that includes qualifying, quantifying, scoring, and reviewing tomographic data.

Corneal tomography is a new term—broader than what is known as *corneal topography*. Recently, the latter is used only to describe the features of the anterior corneal surface, whereas the former is used to describe the features of both corneal surfaces and the matter in between, creating a basic 3-D map of the cornea. It helps us select appropriate candidates for refractive surgery by qualifying the tomography and quantifying corneal features to confirm information gathered in the clinical examination. It also aids in the diagnosis and treatment of ectatic corneal diseases such as keratoconus, forme fruste keratoconus, pellucid marginal degeneration, and post-LASIK ectasia. Furthermore, corneal tomography is a substantial component of planning refractive procedures, including LASIK and PRK, and evaluating their results.

MOST COMMONLY USED MAPS

Corneal tomography produces a graphic representation of corneal features via multiple tomographic maps. A lot of helpful information can be gathered from these maps; however, understanding what each of these types of map tells us can be daunting. The most common tomography maps we use to diagnose and treat ectatic disorders are the axial (sagital) map, the local (tangential) map, the elevation map, and the thickness map.

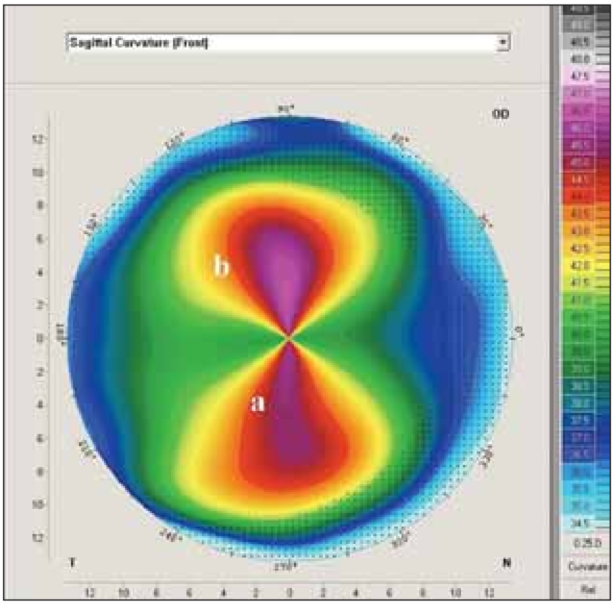

Figure 1. On corneal topography, an eye with regular astigmatism will resemble a bowtie with two symmetric segments.

The term *topography* describes the axial and local maps, and the term *tomography* describes all of these maps, including topography. Below is an overview of how each map can be used to identify risk factors for corneal ectatic disorders. When looking for risk factors on curvature maps, I divide my search into two groups: shape and parameters. Each will be discussed below.

Sagital map. This map shows the least amount of detail compared with the others, as it provides a view of the curvature across the entire cornea. Generally speaking, the axial map does not show minor variations in corneal curvature; however, it does use colors to represent the curvature and dioptric values at different spots across the cornea. The hotter colors (reds and oranges) represent steeper areas and the cooler colors (blues and greens) represent flatter areas.

Tangential map. Corneal irregularities are often locat-

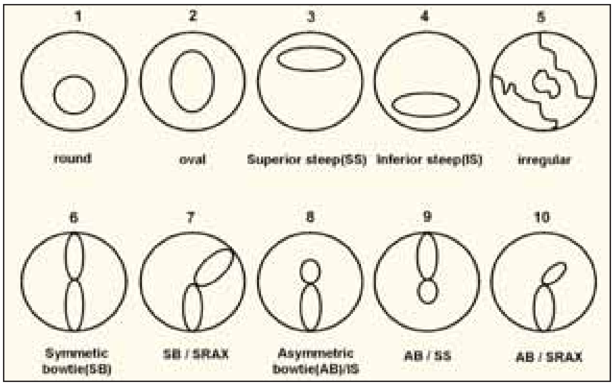

Figure 2. Depiction of corneal irregularities; the symmetric bowtie in No. 6 depicts the normal shape of the cornea.

ed on the anterior surface of the cornea, with two common causes being tear film disturbances and contact lens warpage. This is perhaps the most important map to consider when diagnosing corneal ectatic disorders. Just like on the axial map, colors are used to represent the curvature and dioptric values across the cornea, but this curvature map more closely resembles the true corneal shape and depicts these changes with more precision. This map can also pinpoint the position of corneal defects such as cone location in keratoconus.

Shape. On corneal topography, an eye with regular astigmatism will be represented by a bowtie pattern with two symmetric segments (Figure 1). If the symmetric bowtie is vertical, the eye has with-the-rule astigmatism; if it is horizontal, the astigmatism is against-the-rule; and if it is diagonal, oblique astigmatism is present. Additionally, the curvature map picks up corneal irregularities, or hot spots that have abnormal keratometry (K) readings. These irregularities can be described as round, oval, superior steep, inferior steep, irregular, symmetric bowtie, symmetric bowtie with skewed radial axis (22° or greater difference), inferiorly steep asymmetric bowtie, superiorly steep asymmetric bowtie, or asymmetric bowtie with skewed radial axis (Figure 2). With the exception of the symmetric bowtie, the normal shape of the cornea, these patterns are risk factors for corneal ectatic disorders when they are accompanied by abnormal tomographic parameters, which are described below.

Parameters. Within the 5-mm central circle on the corneal curvature map, the symmetrically opposite superior and inferior numbers should be compared. When the superior number is more than 2.50 D greater than the lower number, or when the inferior number is more than 1.50 D greater than the upper number, there is a risk for corneal ectatic diseases.

Elevation map. The purpose of this map is to depict the height at which corneal elevations and depressions deviate from a computer-generated reference surface. Shades of red show elevations, and shades of green or blue show depressions.

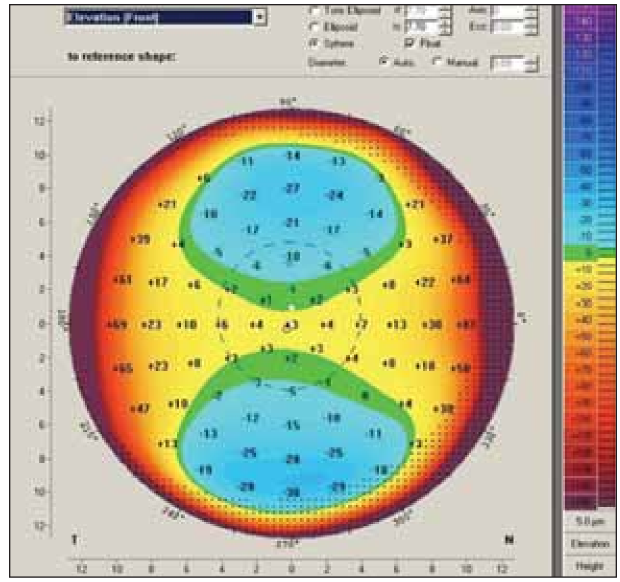

Figure 3. An elevation map with an hourglass-like pattern denotes that the eye is normal.

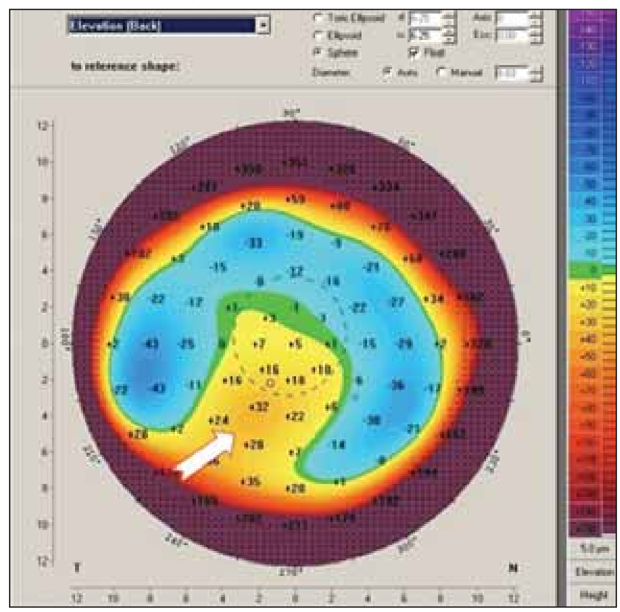

Figure 4. An elevation map with a tongue-like pattern (arrow) denotes that the eye is likely to have some type of corneal ectatic disorder.

Shape. The elevation map of a normal eye has an hourglass-like pattern (Figure 3). If the elevation map shows a tongue-like pattern (Figure 4), this is suspicious and may likely mean that the eye has some type of corneal ectatic disorder. The Belin/Ambrosio Enhanced

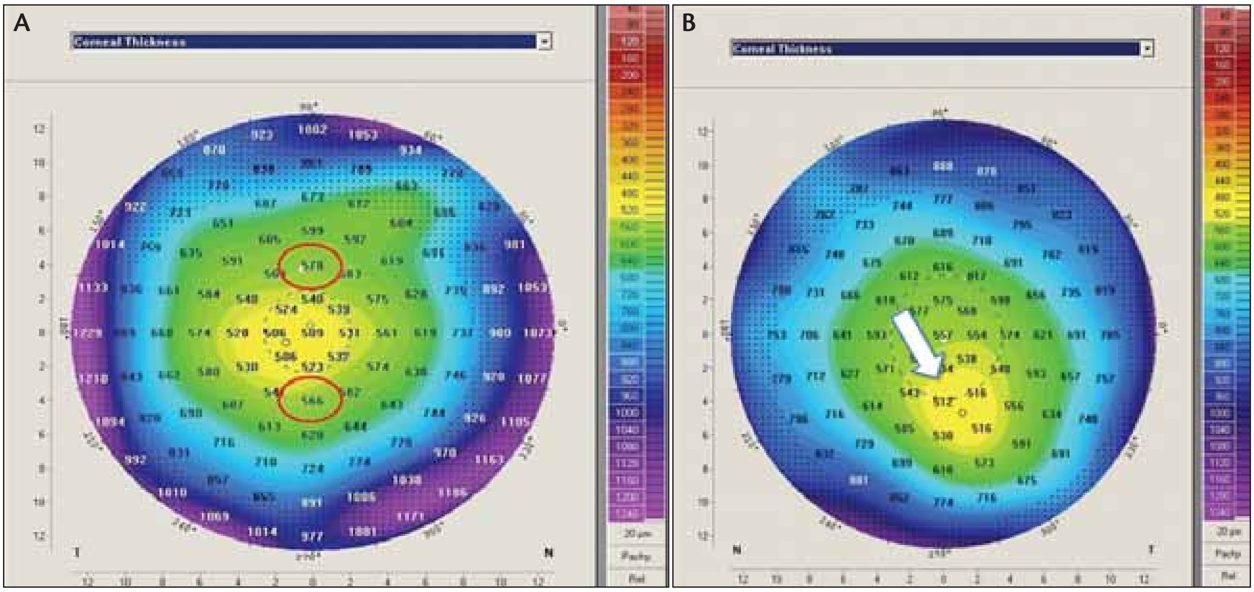

Figure 5. Difference between (A) normal and (B) abnormal corneal thickness map shapes.

Ectasia Display (BAD) on the Pentacam (Oculus Optikgeräte GmbH) simplifies interpretation of the elevation map, with the display of anterior and posterior elevation data shown relative to a standard best-fit-sphere calculated at an optical zone fixed at 8.0 mm. Additionally, the BAD performs regression analysis on changes in anterior and posterior elevation, corneal thickness at the thinnest point, thinnest point displacement, and pachymetric progression. It also generates standard deviations (SD) from the mean. Using these values, the BAD creates a new overall map reading, applying colors to represent variations from the mean. Yellow indicates a suspicious cornea (at least 1.6 SD from the mean), and red indicates an abnormal cornea (at least 2.6 SD from the mean). White values indicate a normal cornea.

Parameters. The central circle on the elevation map is 5 mm; using the toric ellipsoid mode, values greater than 12 µm on the anterior elevation map and 15 µm on the posterior elevation map are considered abnormal.

Thickness map. The BAD is also useful when interpreting the thickness map. The most important consideration on this map is the displacement of the thinnest corneal location.

Shape. Figure 5 illustrates the difference between a normal and an abnormal corneal shape. In the abnormal cornea, the thinnest point (yellow) is displaced inferiorly or inferotemporally, and in the normal cornea the central area is of a generally uniform thickness (green).

Parameters. For this map, the superior and inferior values, the thinnest location of both eyes, the thickness of the pachymetry apex and thinnest location, and the Y coordinate of the thinnest location should be compared. The difference between superior and inferior values as well as the difference between the thinnest locations of both eyes should be less than 30 µm. Additionally, pachymetry thickness and the thinnest location should be no more than 10 µm apart. Lastly, if the Y coordinate is less than -500 µm, the cornea is normal; however, if it is between -500 and -1,000 µm, the cornea is suspicious, and if it is greater than -1,000 µm it is abnormal.

SYSTEMATIC APPROACH

To alleviate the complexity of reading each and every tomography map, a systematic approach to interpreting corneal topography is advised. This has four basic steps.

Qualify. Qualification of the patient's complete tomography is the first step to reading tomography. Use of a checklist (Table 1) is helpful to ensure that any sign of corneal ectatic disorders is not missed.

Quantify. Here, correlations between the patient's clinical data, including age and manifest refraction, and the tomographic findings should be identified. These correlations can be used to judge whether the refractive error can be treated.

Score. A scoring system such as the Ectasia Risk Score System[1] that uses topography, age, residual stromal bed thickness, central thickness, and manifest refraction to score a patient's risk for corneal ectatic disorders is suggested. This index helps to determine the likelihood of corneal ectasia based on the patient's data and to screen out poor candidates for corneal refractive surgery.

TABLE 1: NORMAL, SUSPECT, AND ABNORMAL FINDINGS IN CORNEAL TOMOGRAPHY			
	Normal value(s)	**Suspect value(s)**	**Abnormal value(s)**
Quality specification	White	Yellow	Red
Keratometry (K) readings:	Look at flat K for myopic treatment Look at steep K for hyperopic treatment		>48 D
Corneal astigmatism	Compare with manifest astigmatism		>6 D
Average Q value (vertical and inferior Q values) topometric map	0 to -1	-0.50 to -0.55	]0,-1[>-0.55
Thinnest location			
Thickness (μm)	>500	470 to 500	<470
Difference with pachymetry apex thickness (μm)	<5	5 to 10	>10
Coordinates (μm)	<500	500 to 1,000	>1000
Pupil center coordinates	Important for treating hyperopia and >3.00 D of astigmatism		
KPD (D)	<0.75	0.75 to 1.50	>1.50
Anterior curvature map			
Maximum K (K-max)	Important when treating hyperopia		
Pattern	Refer to topographic patterns		
I-S Rabinovich ratio			>2
Skewed steepest radial axis index			>22°
Superior-inferior difference within the 5-mm circle			>1.50 D when the inferior is steeper >2.50 D when the superior is steeper
Elevation maps (within the 5-mm central circle)			
Anterior on toric ellipsoid mode (μm)	≤12	13 to 15	>15
Posterior on toric ellipsoid mode (μm)	≤17	18 to 20	>20
Isolated island (or tongue-like extension) on sphere mode	Might be an indicator for forme fruste keratoconus		
Corneal thickness map			
Shape		Cone-like	
Superior-inferior difference (μm)	<30	>30	
Thinnest location difference between both eyes (μm)	<30	>30	
Keratoconus diagram			
Shape and location of the curve		– Out of normative range – Deviation before the 6-mm circle	
Average	1	1.1 to 1.2	>1.2
Indices of irregularity	White	Yellow	Red

TAKE-HOME MESSAGE

- Corneal tomography creates a basic 3-D map of the cornea to depict the features of the corneal surfaces and the matter in between.
- The tangential map is perhaps the most important map to consider when diagnosing corneal ectatic disorders.
- Using a systematic approach simplifies the process of reading and interpreting topography data.

Review. As a last step, it is important to assess the data obtained during the previous three steps and review how it affects the patient's diagnosis. After reviewing all data, the surgeon should have enough information to decide whether refractive surgery is an appropriate option.

CONCLUSION

Corneal tomography is an integral part of the diagnostic process that all refractive surgeons use to select appropriate candidates for refractive surgery. Although the data that tomographers provide are likely to change as software improves, employment of a systematic approach to reading and interpreting topography data is likely to remain important for the correct interpretation of the many types of information provided by these devices.

When interpreting corneal tomography seems overwhelming, take a step back and remember to first address the four simple steps outlined in this article: qualify, quantify, score, and review tomographic data. ■

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