Colour maps to aid differential diagnosis of corneal diseases

R.M. García-Monlleó, M. Melgosa, R. Huertas and F.J. Bermúdez
Departamento de Óptica, Facultad de Ciencias, Universidad de Granada
18071-Granada (SPAIN)
Corresponding author: R. García-Monlleó (rosamgm@ugr.es)

ABSTRACT

We have analyzed corneal topographies from 100 patients, to determine from the colour map whether some pathology truly exists, in doubtful cases in which clinical signs are scarce. We used an EyeSys 2000 corneal topographer to perform a differential diagnosis, based on colour distribution in the topographical map. We used colour to classify morphologically the cases of keratoconus already diagnosed and to determine the most appropriate treatment. Also, we performed spectroradiometric measurements on the monitor screen, to study the relationship between the colour scale provided by the EyeSys 2000 topographer and the corresponding dioptric powers. We conclude that colour maps are an effective tool for differential diagnosis between keratoconus and pellucid marginal degeneration, diseases that are often confused without this method. The 15 colour samples provided by the EyeSys 2000 topographer are distributed with acceptable regularity in CIELAB colour space, except the three blue samples associated with the lowest dioptric powers.

Keywords: Corneal topography; colour maps; corneal diseases; keratoconus; pelludid marginal degeneration.

1. INTRODUCTION

Corneal topography seems to be a valuable tool for the study of corneal irregularities, which by other methods would not be detectable. This technique provides important information on physiologically normal corneas as well as on those that present some type of pathology, have suffered some traumatism, or have undergone different types of surgery. Most current topographers have various options to present their results, both qualitatively and quantitatively, including the use of different colours to indicate dioptric power. In most topographical maps, the colours of short dominant wavelength (blues) are associated with low refractive-power values (large curvature radii), while colours of long dominant wavelength (reds, oranges and yellows) correspond to high refractive power (small curvature radii). By comparison with the topographical patterns considered as normal[1], a topographer may allow the diagnosis of corneal keratopathies such as pellucid marginal degeneration, keratoconus, or keratoglobus, and then enable these diseases to be classified and evaluated for possible treatment.

Pellucid marginal degeneration is an uncommon cause of inferior peripheral corneal ectasia, affecting patients of 20 to 40 years of age. This degeneration is characterized by a peripheral thinning band of the lower cornea from the 4 to the 8 o'clock position, and typical topographies have a classical croissant appearance, demonstrating large amounts of against-the-rule astigmatism (see Figure 1).

Keratoconus is a non-inflammatory corneal disease that reduces vision as a result of irregular myopic astigmatism and corneal scarring. It is typically present in the late teen-age years. It is most commonly bilateral and its progression is variable and often asymmetrical. Early or mild forms of keratoconus are detectable only by examination of corneal topography.

Keratoglobus is a rare disorder in which the entire cornea is thinned, most markedly near the corneal limbus, in contrast with the localized thinning (centrally or paracentrally) which characterizes the keratoconus. Keratoglobus is bilateral, but it is usually present from birth and tends to be non-progressive.

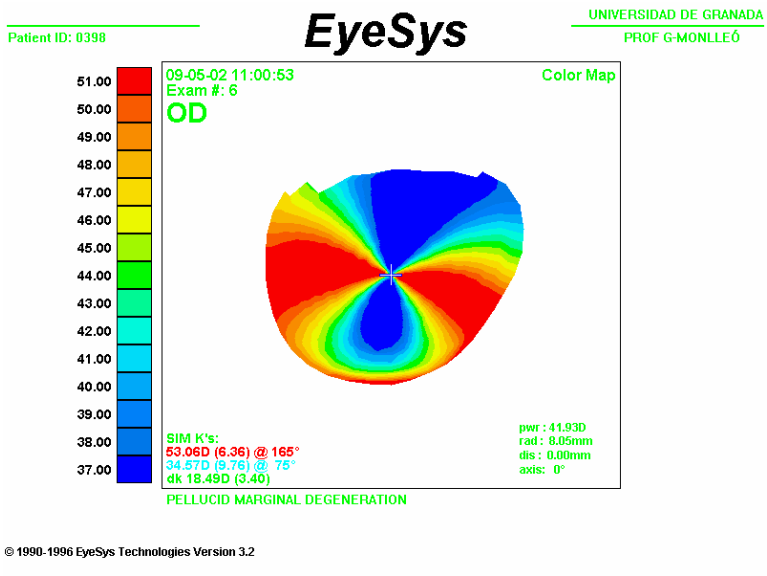

Figure 1: Example of a colour map characteristic of pellucid marginal degeneration.

It is important to be able to distinguish keratoconus from other ectatic dystrophies and corneal thinning disorders, such as pellucid marginal degeneration and keratoglobus, because the management and prognosis of these disorders differ markedly from those of keratoconus. In addition, it should also be useful to test whether the current colour scale provided by commercial topographers is adequate for these goals.

2. METHOD

We used an EyeSys 2000 corneal topographer, which makes 360 equally spaced angled measurements at each of the 18 rings that are reflected on the anterior corneal surface, providing about 6480 data (some peripheral measurements are usually lost). We have evaluated the results obtained with this instrument for 100 patients, using an iso-dioptric colour map, which indicates the curvature radius of each point measured on the corneal surface, with respect to the optical axis of the cornea assumed to be spherical. This is one of the maps most often used in clinical practice because of its excellent repeatability and speed in detecting anomalies. It provides a good view of the overall corneal surface, enabling a differential diagnosis even in the first stages of the disease[2], when there are no symptoms or obvious clinical signs. Of the 100 patients examined, some of them already presented symptoms or clinical signs that indicated the presence of keratoconus, and others appeared to have some corneal anomaly, still to be determined.

We analysed the colour scales that accompanied the topographical maps by using a SpectraScan PR-650 spectroradiometer measuring colours on the monitor screen. The measurements were performed in a dark room, with the spectroradiometer positioned on an appropriate tripod placed in front of the CRT monitor, at the position usually occupied by the operator of the EyeSys 2000 topographer. The relationship between the different colours shown in the monitor and the reported dioptric values were analysed in CIELAB colour space[3]. The CIE 1931 Standard Observer was assumed, and the reference white for transformation to CIELAB was the one corresponding to our CRT monitor.

3. RESULTS

The analysis of the results show that of the 100 people examined (200 eyes), 80 presented keratoconus in different degrees (91.25% binocular and 8.75% monocular), 3 subjects suffered pellucid marginal degeneration and 17 people had different types of astigmatism (18 eyes regular

astigmatism according to the rule, 10 eyes regular against-the-rule, and 6 eyes irregular astigmatism). The colour map made it possible to detect 23 cases of keratoconus, which were unknown until that moment by the patients. Our results confirm the usefulness of colour when confronted with the difficulty of diagnosing keratoconus in its initial stages, when subjective symptoms and clinical signs are still not patent. An example of this type of situation is shown in Figure 2. In addition, by the use of colour maps, we have morphologically classified the 153 cases of keratoconus (73 binocular and 7 monocular) in order to determine the most appropriate treatment[4], finding 17 in the form of a nipple, 63 in the form of an oval, 15 round, and 58 in the form of an asymmetric bowtie with inferior steepening.

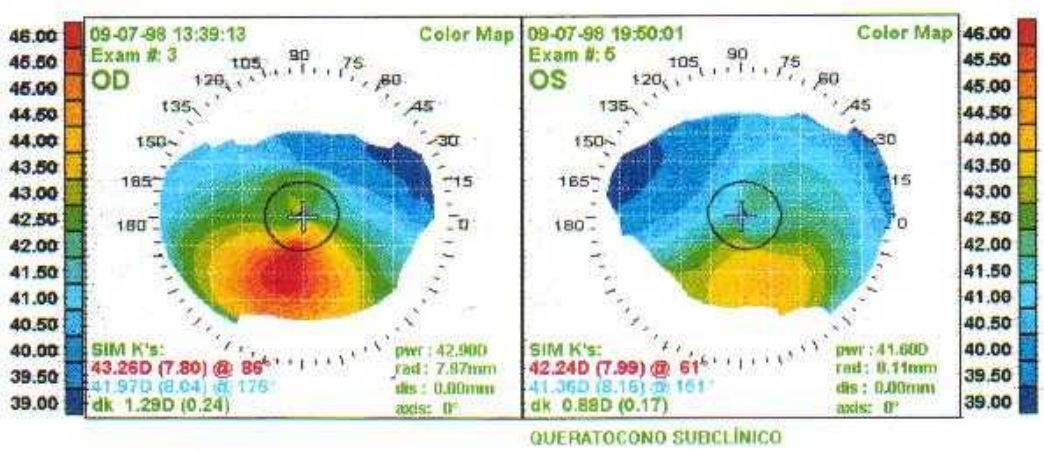

Figure 2: Example of a colour map characteristic of bilateral asymmetric keratoconus, in which the left eye showed no subjective sign or clinical symptom.

Figure 3 shows the CIELAB coordinates of the 15 colours employed by the EyeSys 2000 topographer to codify dioptric powers. In particular the plot corresponding to the a*b* plane shows that the provided colours are distributed with reasonable regularity, except the samples 1, 2 and 3, all of them in the blue region. Sample 1 seems to be far away of their related ones, while samples 2 and 3 are very similar. Except for samples 2 and 3, we note that there are large colour differences between contiguous samples, clearly distinguishable by observers with normal colour vision (Figure 4).

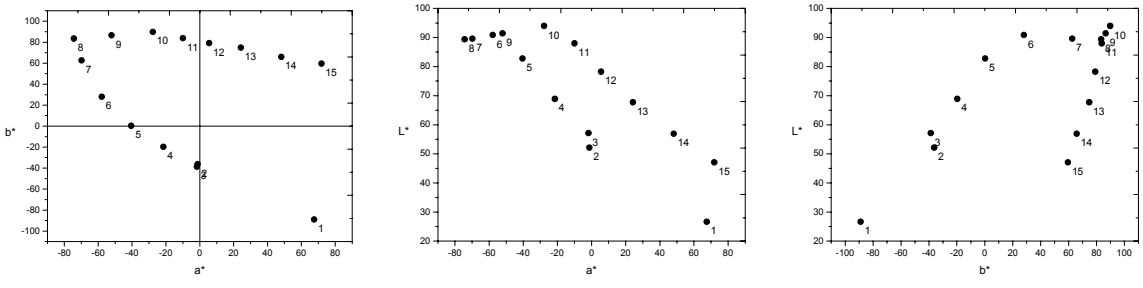

Figure 3: CIELAB coordinates for the 15 samples of the scale provided by the EyeSys 2000 topographer measured by the SpectraScan PR-650 spectroradiometer.

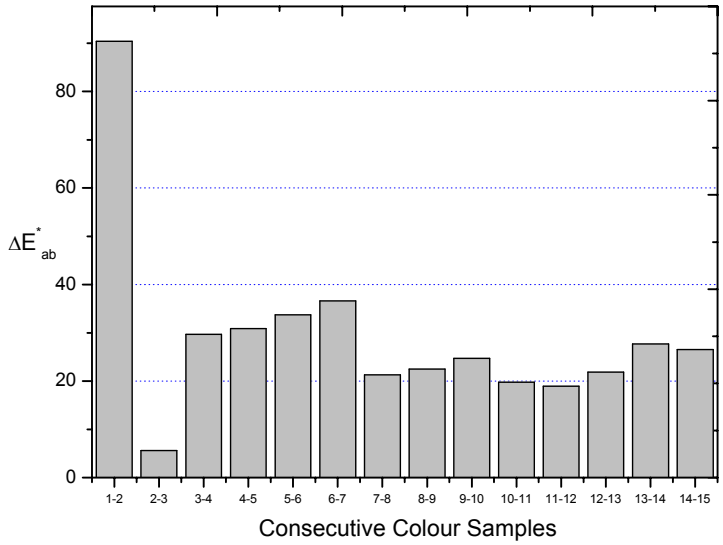

Figure 4: CIELAB colour differences between contiguous samples in the scale of the EyeSys 2000 topographer, from measurements on CRT monitor.

4. CONCLUSIONS

Clinically apparent and unapparent keratoconus can be detected among normal and irregular corneas using the colour maps of the EyeSys System 2000, providing a valuable tool for differential diagnosis between the keratoconus and pellucid marginal degeneration[5], diseases that are often confused without this method. The colour scale provided by the EyeSys System 2000 seems to be appropriate, except for the three samples related to the lowest dioptric powers.

Acknowledgment
Research Project FIS2004-05537, Ministerio de Educación y Ciencia, Spain.

REFERENCES

1. Y. S. Rabinowitz, H. Yang, Y. Brickman, J. Akkina, C. Riley, J. I. Rotter and J. Elashoff, "Videokeratography database of normal human corneas," British Journal of Ophthalmology, 80, 610-616 (1996).
2. L. J. Maguire and W. M. Bourne, "Corneal topography of early keratoconus," American Journal of Ophthalmology, 108, 107-112 (1989).
3. CIE Pubication 15-2. "Colorimetry", 2nd Ed. CIE Central Bureau, Vienna, 1986.
4. P. J. Caroline, J. R. McGuire and D. J. Doughman, "Preliminary report on a new contact lens design for keratoconus," Contact Intraocular lens, 4, 69-73 (1978).
5. R. M. Santo, S. J. Bechara and N. Kara-José, "Corneal topography in asymptomatic family members of a patient with pellucid marginal degeneration," American Journal of Ophthalmology, 127, 205- 207 (1999).