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## Original article

# Correlation of higher order aberrations in the anterior corneal surface and degree of keratoconus measured with a Scheimpflug camera<sup>☆,☆☆</sup>



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## ABSTRACT

**Objective:** To determine the correlation of higher order aberrations in anterior corneal surface and degree of keratoconus measured with a Scheimpflug camera.

**Material and methods:** A descriptive, cross-sectional study was conducted on 152 eyes (both eyes of each patient) of patients with keratoconus, from January 2009 to April 2014. An examination was performed on the corneal aberrometry in the anterior corneal surface, and topographic mapping (by Amsler and Muckenhirn classification) was used to determine the degree of keratoconus. The correlation between high-order aberrations in anterior corneal surface and the degree of keratoconus was determined.

**Results:** Coma aberration significantly correlated with keratoconus severity ( $r = .60, p < 0.01$ ), as well as with the high order aberration ( $r = .61, p < 0.01$ ). Trefoil and keratoconus were weakly correlated ( $r = .34, p < 0.01$ ).

**Conclusion:** Higher order aberrations in anterior corneal surface were positively correlated with the degree of keratoconus in a similar way to the entire optical system.

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## Correlación de aberraciones de alto orden en la cara anterior de la córnea y el grado de queratocono medidas con cámara de Scheimpflug

### R E S U M E N

#### Palabras clave:

Aberraciones de alto orden  
Scheimpflug  
Queratocono  
Coma  
Trefoil

**Objetivo:** Determinar la correlación de las aberraciones de alto orden en la cara anterior de la córnea y el grado de queratocono medidas con cámara de Scheimpflug.

**Material y métodos:** Se realizó un estudio descriptivo y transversal en 152 ojos de pacientes (ambos ojos de cada paciente) con queratocono, desde enero del 2009 hasta abril del 2014. Se analizaron las aberraciones en la cara anterior de la córnea y se utilizó el mapa topográfico (clasificación de Amsler y Muckenhirn) para determinar el grado de queratocono y encontrar la correlación que existe entre las aberraciones de alto orden en la cara anterior de la córnea y el grado de queratocono.

**Resultados:** La aberración coma se correlacionó significativamente con la severidad del queratocono ( $r=0.60$ ;  $p<0,01$ ); de la misma forma que la aberraciones de alto orden ( $r=0,61$ ;  $p<0,01$ ). Trefoil y el grado de queratocono se correlacionaron en menor medida ( $r=0,34$ ;  $p<0,01$ ).

**Conclusiones:** Las aberraciones de alto orden en la cara anterior de la córnea se correlacionan de forma positiva con el grado de queratocono, por lo que deberían ser consideradas en el abordaje diagnóstico de dicho padecimiento.

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## Introduction

Keratoconus is a bilateral non-inflammatory corneal ectasia which leads to protrusion, distortion and scarring of the cornea.<sup>1</sup> The clinical signs are well defined, but early forms of the disease can go unnoticed unless a topographical study is performed.<sup>2</sup>

It is an uncommon condition; the annual incidence is estimated to be approximately one in every 2000 inhabitants. It affects all ethnic groups and has no gender predominance. In an assessment of corneal topography of first-degree relatives of patients with keratoconus, an incidence of 11% was found, compared with 0.05% in the general population.<sup>3,4</sup>

Although there are several hypotheses, the cause remains unknown. Most of the time it is an isolated condition.<sup>5</sup> Some studies have identified hereditary factors as risk factors in keratoconus.<sup>6</sup>

It has also been associated with various syndromes such as Marfan's and Down's; between 0.5% and 15% as a possible result of rubbing the eyes, due to the high rate of blepharitis in this population. Other conditions such as atopy, use of contact lenses, eye trauma, connective tissue disorders and mitral valve prolapse have also been involved.<sup>7</sup> Proinflammatory cytokine levels have been found to be elevated in keratoconus tears compared to a control group, indicating the development of chronic inflammatory events in the pathogenesis of the disease.<sup>8</sup>

Recent studies have evaluated the Shack-Hartmann wavefront sensor, which has proven its accuracy for obtaining the refraction value and measuring the eye aberrations without altering the accommodation state.<sup>9</sup>

In 2009, an article was published in the *Revista Mexicana de Oftalmología* [Mexican Journal of Ophthalmology] on a study of

55 eyes, which found that vertical coma is the predominant higher-order aberration in eyes with keratoconus and spherical aberration is a significant parameter for distinguishing between the different stages of keratoconus.<sup>10</sup>

It is now known that aberrations on the anterior surface of the cornea have greater involvement in patients with keratoconus.<sup>11</sup>

In patients with keratoconus, the anterior corneal surface is the most important source of optical errors. It is reported that in patients diagnosed with keratoconus, there is a greater presence of vertical coma aberrations.<sup>12-14</sup>

Aberrometry uses wavefront sensors to measure the complete refractive status, including irregular astigmatism in the optical system. In physical optics, light is expressed as a wave and light waves dissipate in all directions, like a spherical wave.<sup>15</sup> The wavefront is the form of light waves in the input stage; light from infinity is perceived as a planar wavefront.<sup>5</sup>

Unlike the topographic analysis, wavefront technology can detect subclinical keratoconus with a sensitivity and specificity of 91% and 94% respectively.<sup>13</sup> Other biomechanical factors of the cornea need to be considered.<sup>16</sup>

When beginning to interpret wavefront maps, the Optical Society of America (OSA, 2000) recommended the expansion of Zernike polynomials as the standard method for representing the error in the wavefront of an optical system. These are considered the basic description or building blocks of any wavefront. Corneal aberrometry can determine corneal optical aberrations, which constitute 80% of all total ocular aberrations.<sup>17</sup>

Higher-order aberrations (HOA) have been studied many times for refractive surgery. Maeda et al. applied wavefront technology to study aberrations in eyes with keratoconus.<sup>18</sup>

Wavefront technology is having an increasingly major impact on clinical practice: the correction of ocular aberrations

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