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The use of Zernike and Q-Polynomials combined for the Representation of Intraocular-Lens Topologies

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Abstract content :

Intraocular lenses (IOLs) have gained a momentum in their development in the last few years as new technologies and materials became available. They are alternative to the natural crystalline lens of the eye in several clinical conditions, especially cataract, which is the most important cause of blindness in the world. IOLs can be divided into three main groups: monofocals, torics and multifocals. This paper focuses on the refractive monofocal IOLs that differ from each other according to the shape of the surface (i.e. spherical or aspheric) and dioptric power. Spherical lenses present peripheral distortion reducing contrast sensitivity. This is minimized with aspheric lenses, based on a conic, usually hyperbolic, topology. There are numerous possibilities to mathematically represent IOL surfaces. In Ophthalmology, Zernike polynomials have been historically employed as the orthogonal basis for the precise description of recurrent eye-lens topologies as defocus, astigmatism, spherical aberration and coma. However, Zernike polynomials present limitations when describing aspheric surfaces, often requiring a large number of terms for their representation. Recently, Forbes proposed a group of orthogonal polynomials, also known as Q polynomials, that ease the representation and manufacturability of aspheric surfaces [1]. This paper compares the reconstruction of aspheric monofocal IOL surfaces sequentially using the first couple of Zernike and Forbes polynomial terms. We, therefore, propose the investigation of the reconstruction of both rotationally symmetric and asymmetric IOL surfaces in two steps that can be performed in the reverse order as well: 1) reconstruction with the first Zernike terms and 2) reconstruction of the residual surface with Forbes polynomials. This analysis verifies whether the combination of both polynomials renders the reconstruction of relevant ophthalmic surfaces with a prescribed precision and using fewer terms than required by each basis individually.We believe that successful results will also have a direct impact on adaptive optical systems.**References**[1] G. W. Forbes, "Characterizing the shape of freeform optics," OPTICS EXPRESS, vol. 20, pp. 2483-2499, 30 January 2012

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