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Biomechanical analysis of symmetric and antisymmetric modes in corneal deformation profiles

Abstract:

The recorded deformation profiles of the cornea under new non-contact tonometry with a high-speed camera provide valuable insights into identifying corneal diseases through biomechanical alterations. Previous researches, driven by the importance of distinguishing keratoconus through the integration of corneal apex deformation and tomographic severity, have proposed several indices for diagnosis. However, prior studies have overlooked characteristics of the entire corneal profiles during deformation, leading to a gap in understanding the mechanical properties and their application. To analyze these corneal profiles, we used mathematical decomposition techniques to break down the geometric shapes of corneas into several modes with modal coefficients. Then we recorded these modal coefficients as time-sequential curves. By analyzing these time-sequential curves from 500 normal, 200 keratoconus, 250 post-reflective surgery, and 100 glaucoma subjects, we identified several features from these modal coefficients, which could be categorized into symmetric and antisymmetric categories. These findings suggest that features in the symmetric category are associated with major deformations, such as intraocular pressure measurements and eyeball movement. High-order modes in the symmetric category are linked to characteristics following reflective surgeries (PRK, LASIK, and SMILE) and the bowtie patterns of keratoconus (AB/IS and AB/SS). Conversely, features in the antisymmetric category are associated with misalignment during testing, primary angle closure glaucoma, and lateral behaviors of forme fruste keratoconus. In conclusion, our method emphasizes the importance of considering the entire corneal profiles, as their categories reveal distinct behaviors. These insights offer potential for improved diagnosis by providing greater details on corneal biomechanics.

Biography

Po-Jen Shih completed his PhD in the Civil Engineering Department at National Taiwan University (NTU), focusing on computational mechanical analysis. He then pursued postdoctoral studies in Mechanical Engineering at NTU, specializing in the fabrication of MEMs. Currently, he serves as an associate professor in the Biomedical Engineering Department at NTU. He applies mechanical analysis technology to address interdisciplinary challenges in the field of biomechanics, particularly focusing on dynamic analysis of corneal biomechanics. He has authored 51 papers in reputable journals.