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Contribution - A Finite Element Study on the Biomechanics of Intracorneal Implants in Keratoconus Corneal Models

DS applications and challenges in Medicine, Natural Sciences, and Engineering

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Abstract

Keratoconus (KC) is a progressive corneal disease characterized by thinning, weakening and steepening of the cornea. KC progression is manifested by corneal protrusion, irregular astigmatism and severe unilateral and bilateral myopia. The prevalence is 0.05% in Western countries but higher in the Middle East and Asia (0.76% - 3.30%). KC-associated anatomical deviations strongly impact the patient's vision and quality of life. Few-micron alterations of the corneal geometry change the corneal optical power up to several diopters, affecting ophthalmic surgical plans. The etiology of KC is not well understood and there is no cure. In absence of proper intervention, long-term evolution of the disease could cause blindness or require corneal transplantation. Thus, it has recently brought KC interventions into focus. In the past decade, different modalities of KC treatment are gaining interest due to cases of acceptable outcomes. Intracorneal ring segment (ICRS) implantation proved to be a clinically effective approach in flattening the corneal curvature in more advanced stages of the disease. In this regard, empirical nomograms are used by clinicians to define the surgical planning. Nomograms provide a homogenized view of the treatment as individual anatomical and mechanical features are not explicitly accounted for. Thus, the clinical expertise input is needed to address this lack of knowledge. This expertise is not based on objective metrics. On the other hand, reportedly unacceptable refractive outcomes could require corneal transplant as the final approach of KC treatment with major drawbacks such as graft rejection and KC recurrence. Therefore, ring implant simulations are clinically of high importance in prediction of post-surgical deformation and internal stresses. Thus, we are investigating geometrical features of ICRS surgeries to propose personalized sets of segments based on each patient's corneal topographic maps.