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Estimate Corneal Remodelling in Response to Intracorneal Ring Segments

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Abstract

Purpose: To present a robust finite element (FE) modelling based method that can predict the performance of intracorneal ring segments (ICRSs) on the eye and predict the corneal remodelling.

Methods: The study utilises a record of 38 clinical cases of ICRS fittings. Records of Pentacam tomography data from Brazilian participants aged 65.4±15.2 were retrospectively assessed pre and one month post the ICRS implementation. The Pentacam raw elevation data was analysed using a custom-built MATLAB master code that is capable of constructing and operating Abaqus software FE models. The code is using the principle of fire-and-forget as it automatically modifies the simulation strategy according to the Abaqus stability performance without user intervention. This advanced approach to build a custom-built fully automated computer code allowed for the full completion of the FE modelling successfully. Consequently, the code triggers a set of scripted Python codes to extract the analyses outcomes and process them in an autonomous validation process.

Results: Each of the clinical cases' postoperative data were used to validate the relevant model by comparing the tangential curvature within the central 4 mm diameter. The minimum error recorded was 0.01±0.91 mm and the maximum was 0.72±0.92 mm. Validation error between the FE model and the clinical record did not strongly correlate to Pentacam pre and postoperative clinical parameters in cases fitted with one ICRS. Validation error strongly correlated with postoperative corneal horizontal radius (R=0.73) and preoperative asphericity Q (R=0.78) and CCT (0.7) in cases fitted with two ICRSs.

Conclusions: The presented method allows clinicians to predict the outcome of ICRS procedures without performing the surgery, therefore, allowing them to adjust their plans in order to get the best outcome. The method is simulation-based and has zero risks on the patient as it utilises the usual clinical measurements taken from the subject before the surgery such as topography and intraocular pressure with no additional measurements. The achieved results open the door to further future research that could replace ICRS nomograms with reliable methods.

Topics

- CXL pre-clinical, translational