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Biomechanically-driven simulations of the MyoRing treatment in subjects with high myopia

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Abstract

Purpose : Corneal biomechanics is a determinant factor for the outcome of continuous intracorneal segments (MyoRing, Dioptex GmbH). However, implant selection remains driven by optical parameters such as the average central curvature of the cornea (Kmean) and the Spherical Equivalent (SE), while failing to account for the tissue biomechanics or the intraocular pressure (IOP). We hypothesize that biomechanical models and computer simulation can improve the refractive outcomes of the MyoRing treatment.

Methods : Four thousand computer models representing the population of patients who are candidates for a MyoRing treatment have been created using the finite element method. These numerical models accounted for physiologic variability of the anatomical features (anterior and posterior corneal radius of curvature, corneal thickness, axial length and pupil size) and mechanical properties (corneal biomechanics and IOP). Two MyoRing implants were evaluated on these virtual patients (Myoring size: 280 μm; optical zone: 5 and 6 mm; depth: 60%-75%; laser ablated pocket 5 μm). Refractive outcomes obtained with the biomechanical simulation were compared to previous clinical data (Daxer 2017; Rattan 2018).

Results : Population-based simulations were able to reproduce the refractive correction observed clinically; the average post-surgical Kmean was within ± 0.5 D of

the data reported by Rattan (Fig.1 a), and the distribution of post-surgical SE closely matched the clinical data from Daxer (Fig.1 b). Moreover, our simulation approach allowed us to determine the clinical parameters having the most important contributions to the refractive outcome. For example, we found that the correction in Kmean is strongly related to the pre-surgical thickness, mechanics, and IOP, while the correction in SE is highly affected by the depth of MyoRing insertion.

Conclusions : Biomechanical modelling is able to predict the refractive outcomes of MyoRing implantations. This approach provides a deeper understanding on the mechanisms underlying continuous intracorneal segments, which can be used to improve implant design and further personalize the treatment procedure.

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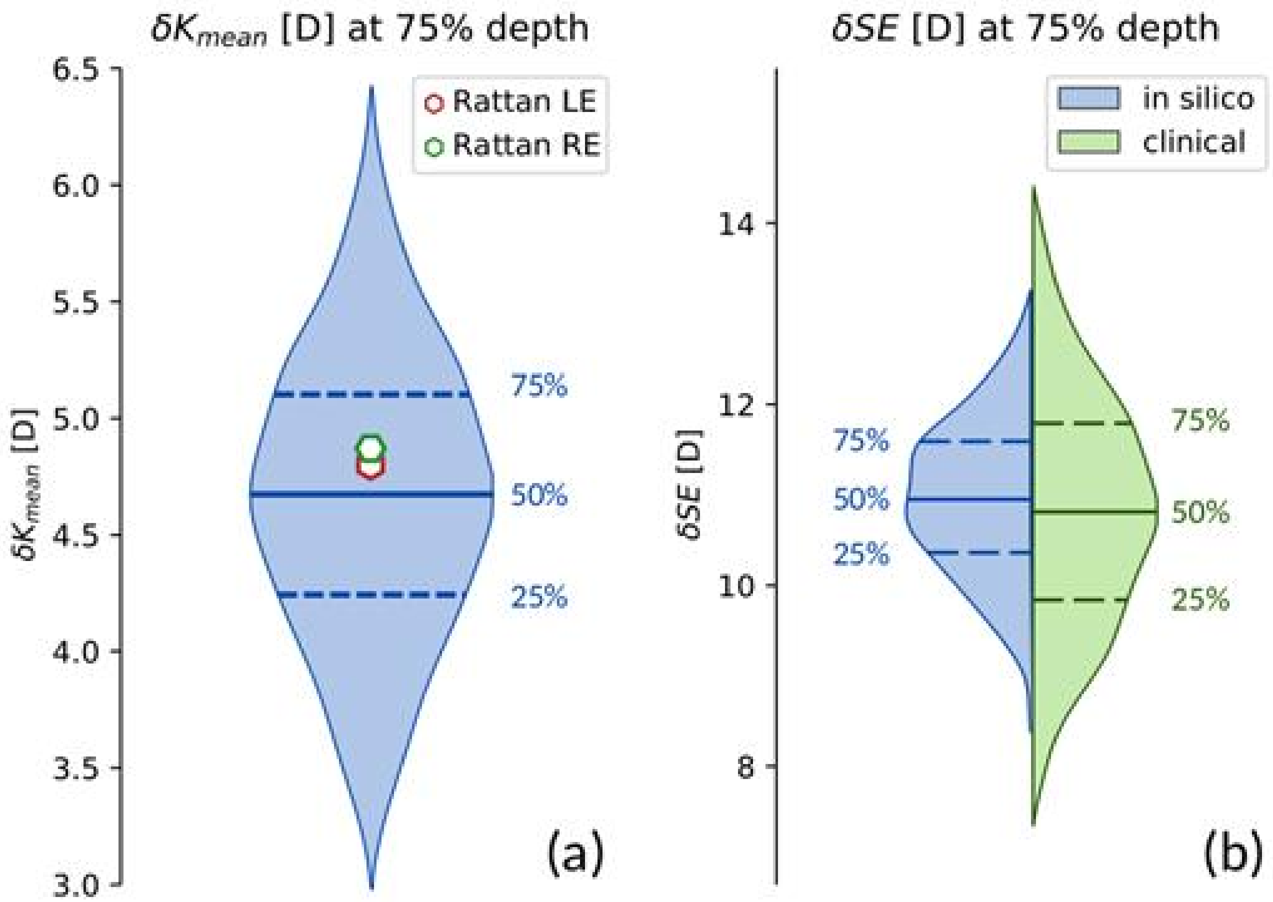

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In silico prediction of correction of K_{mean} (a) and SE (b). Predictions for Myoring insertion are in good agreement with clinical data. A priori knowledge of post-surgical data was not included.