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Corneal biomechanical deterioration with keratoconus progression assessed by the Stress-Strain Index

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Abstract

Purpose: To evaluate the corneal biomechanical deterioration with keratoconus (KC) progression as measured by the stress-strain index (SSI).

Methods: In this retrospective record review, the preoperative of progressive KC cases that were submitted to corneal cross-linking were evaluated. All cases were examined with Pentacam HR and the Corvis ST (Oculus, Wetzlar, Germany). Significant progression was based on the Pentacam's ABCD system. Progression was established when there was a significant change (above the CI 95%) towards kc deterioration in corneal thickness and anterior and posterior surfaces. On the first and last visit before the procedure, the biomechanically corrected intraocular pressure (bIOP), the SSI, the integrated inverse radius (IIR), the stiffness parameter at the first applanation (SP-A1), the maximum corneal apex displacement in the Z direction (DA), the deformation amplitude ratio over 2mm (DA Ratio), were assessed.

Results: A total of 32 eyes fulfilled the inclusion criteria. The mean age at the last exam before the CXL procedure was 22.0 ± 7.7 years (10 - 43). The mean time between the two examinations was 41.4 ± 40.9 months (4 - 145). A spectrum of disease stages was observed at the first examination with KMax of 54.41 ± 4.34 D (44.5 - 64.4) and minimum thickness of 466.72 ± 28.48 μ m (414 - 520). While the bIOP showed non-significant change between the exams (-0.05 ± 1.21 mmHg, range: -2.0 to 2.3, $p = 0.731$), the biomechanical parameters changed between the two time points towards tissue softening. There was significant reduction in the SSI (-0.10 ± 0.06 , range: -0.2 to 0.0, $p < 0.001$) and increase in IIR (0.95 ± 1.04 mm⁻¹, range: -2.34 \pm 2.69, $p < 0.001$). In the same direction towards corneal softening were observed a barely significant increase in DA (0.04 ± 0.13 mm, range: -0.22 to 0.53, $p = 0.056$), a significant increase in central 2mm DA ratio (0.23 ± 0.58 , range: -1.31 to 1.49, $p = 0.034$) and a significant decrease in SP-A1 (-6.1 ± 12.0 mmHg/mm, range: -31.8 to 18.9, $p = 0.011$), however in these last three measures, there was a substantial overlap between the two time points.

Conclusions: It has been observed corneal biomechanical deterioration measured in vivo with KC progression. The SSI and the IIR have been shown to be suitable biomechanical biomarkers of the disease progression.

Topics

- CXL pre-clinical, translational