Original article

Effects of pterygium on the biomechanical properties of the cornea: A pilot study

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ABSTRACT

Objective: To investigate the changes induced by a pterygium or its surgical removal on the biomechanical properties of the cornea and to determine factors that might affect these parameters.

Methods: This prospective pilot interventional, non-randomized, observer-masked study included 20 eyes of 20 patients with a unilateral primary pterygium (pterygium group) and 19 fellow healthy eyes (control group). The bare sclera technique with 1-min application of 0.02% mitomycin C intraoperatively was performed in all cases. The follow-up period was one month. The preoperative and postoperative biomechanical properties of the cornea were measured using the Reichert ocular response analyzer (ORA).

Results: The corneal hysteresis (CH) decreased significantly (p < 0.01) in eyes with a pterygium compared to the control eyes, while surgery did not significantly change the CH compared to preoperatively. There were no significant changes in the corneal resistance factor or the central corneal thickness.

Conclusions: Primary active pterygium (grades 1 or 2) induces a reduction of corneal biomechanical features. Further studies are needed in populations, with longer follow-ups and bigger pterygium that may involve wider keratectomy to confirm our results.

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Efecto del pterigión en las propiedades biomecánicas de la córnea: estudio piloto

RESUMEN

Objetivo: Investigar los cambios inducidos en la biomecánica de la córnea por la presencia de pterigión o por su exéresis quirúrgica, así como determinar los factores que influyen sobre dichos parámetros.

Métodos: Estudio piloto, intervencional y prospectivo, con observador enmascarado que incluía 20 ojos de 20 pacientes con pterigión primario unilateral (grupo pterigión) y 19 ojos del mismo grupo control. Se realizó una resección simple del pterigión con aplicación intraoperatoria de mitomicina C 0,02% durante un minuto sobre el lecho escleral. El período...
de seguimiento fue de un mes. Las propiedades biomecánicas de la córnea fueron determinadas preoperatoria y postoperatoriamente mediante el analizador de respuesta ocular Reichert (ORA).

Resultados: La presencia de pterigión disminuyó significativamente la histéresis corneal (CH) en comparación con el grupo control (p < 0,01). No encontramos diferencias estadísticamente significativas entre las medidas pre- y postoperatorias de la HC, del factor de resistencia corneal, ni del espesor corneal central.

Conclusion: La presencia de un pterigión primario activo (grados 1 y 2) conduce a una reducción de las propiedades biomecánicas de la córnea. Serán necesarios nuevos estudios con un mayor tiempo de seguimiento y pterigones más avanzados, con queratectomías más amplias para confirmar estos efectos.

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Introduction

The characterization of corneal biomechanical properties could constitute a useful tool to evaluate indications and results of pterygium surgery. Knowledge about the biomechanical response of the cornea to superficial keratectomy could improve optic results after pterygium excision. The presence of pterygium and its surgical extraction could affect corneal refraction, including spherical and astigmatic power, as well as the regularity of the ocular surface, with these changes being proportional to the pterygium size.\(^1\)

Corneal hysteresis (CH) reflects the viscoelastic properties of the cornea and indicates its biomechanical integrity. The Reichert ocular response analyzer (ORA, Reichert Ophthalmic Instruments, Depew, NY, USA) enables clinical measurements of CH by means of a patented bidirectional dynamic applanation system.\(^2\) The CH is described as the buffering capacity secondary to the viscoelastic resistance of the cornea against the deformation caused by the air jet issued by the ORA tonometer. The instrument also measures the corneal resistance factor (CRF) and cornea-compensated intraocular pressure (cctOP).\(^2\) CH remains relatively stable throughout the day with very small variations attributable to corneal hydration changes.\(^3,4\) It must be noted that CH changes in diseases such as keratocorne, Fuchs dystrophy, after LASIK-assisted on site keratomileusis and in glaucoma.\(^5,6\) The use of ORA has demonstrated a weak but significant correlation between CH and corneal thickness in healthy eyes. In patients with glaucoma, CH correlates to corneal thickness and is associated to progressive visual field damage.\(^6\)

This paper analyzes the changes induced by pterygium and its surgical extraction on the biomechanical properties of the cornea analyzed with ORA and the factors influencing said parameters.

Materials and methods

Patients

Interventional prospective pilot study with masked observer comprising 20 eyes of 20 patients with unilateral primary pterygium (pterygium group) and 19 opposite healthy eyes (control group). The protocol of the study was approved by the Ethics Committee of the Príncipe de Asturias University Hospital and all patients signed an informed consent. The procedures were adapted to the principles of the Helsinki Declaration for Biomedical Research. The exclusion criteria comprised previous ocular surgery or traumaism, use of contact lenses and ocular or systemic diseases such as diabetes which modified the biomechanical properties of the cornea.

A full presurgery ophthalmological evaluation was made, which comprised best corrected visual acuity (BCVA) minimum resolution angle logarithm (logMAR), refraction, corneal topography, biomicroscopy, applanation tonometry, ultrasound pachymetry and ophthalmoscopy. At the biomicroscopic level, each pterygium was classified according to its transparency.\(^7\) The corneal topography was carried out with a Placido topograph (Atlas 995 unit, Carl Zeiss Meditec Inc., Dublin, USA). In order to avoid interferences on the topographic measures, the eyes with pterygium which invaded the corneal center 4 mm were excluded. The patients were assessed 10 days and one month after surgery, repeating the measurements for BCVA, refraction, corneal topography, ultrasound pachymetry and ORA.

Surgical technique

A simple pterygium resection was performed with intrasurgery application of mitomycin C (MMC) 0.02% during 1 min over the scleral surface. Conjunctival anesthesia was obtained by instilling tetracain chloride eye drops (Colirio anestésico doble\(^7\), AlconCusi, Barcelona, Spain) and 5 ml lidocaine 2% with adrenaline 1:200,000 and 25 G needle subconjunctival injection pterygium body. The pterygium head was dissected with Bard-Parker # 15 scalpel and the body, including the adjacent Tenon capsule, was removed with Wescott scissors, leaving the denuded sclera exposed. A surgical sponge fragment (Microspponge, AlconCusi) impregnated with 0.02% MMC (0.2 mg/ml) was applied directly over the scleral surface during 1 min with subsequent abundance irrigation with balanced saline solution. The conjunctival edges were sutured (7-0 Vicryl, Ethicon) up to 2 mm from the limbus, and the stitches were removed 10 days after the procedure. After the surgery, tobramycin and dexamethasone eye drops (Tobradex\(^8\), AlconCusi) were prescribed 4 times/day/month.
Table 1 – Changes in best corrected visual acuity and refractive parameters before and after pterygium surgery.

<table>
<thead>
<tr>
<th></th>
<th>Control group (n = 19 eyes)</th>
<th>Pterygium group (n = 20 eyes)</th>
<th>p (ANOVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presurgery</td>
<td>10 days postsurgery</td>
<td>One month postsurgery</td>
</tr>
<tr>
<td>BCVA LogMAR</td>
<td>0.03 SD 0.02</td>
<td>0.28 SD 0.12&lt;sup&gt;∗&lt;/sup&gt;</td>
<td>0.14 SD 0.06</td>
</tr>
<tr>
<td></td>
<td>(0–0.09)</td>
<td>(0–0.5)</td>
<td>(0–0.2)</td>
</tr>
<tr>
<td>Refractive spherical power (D)</td>
<td>0.66 SD 1.56</td>
<td>0.63 SD 2.15</td>
<td>0.08 SD 1.78</td>
</tr>
<tr>
<td></td>
<td>(–1.87 to 5.37)</td>
<td>(–6.12 to 3.5)</td>
<td>(–5.12 to 2.75)</td>
</tr>
<tr>
<td>Refractive cylinder (D)</td>
<td>–0.98 SD 1.42</td>
<td>–1.55 SD 0.83</td>
<td>–0.75 SD 0.45</td>
</tr>
<tr>
<td></td>
<td>(–6.62 to –0.25)</td>
<td>(–4 to 0.5)</td>
<td>(–1.87 to 0.25)</td>
</tr>
<tr>
<td>Keratometric astigmatism (D)</td>
<td>1.35 SD 2.38</td>
<td>2.18 SD 1.09</td>
<td>1.12 SD 0.76</td>
</tr>
<tr>
<td></td>
<td>(0.5–5.88)</td>
<td>(0.12–3)</td>
<td>(0–2.25)</td>
</tr>
</tbody>
</table>

Data are expressed in mean values, standard deviation (SD) and range.
ANOVA: variance analysis; D: diopeters; LogMAR: logarithm of minimum angle of resolution; BCVA: best corrected visual acuity.

<sup>∗</sup> Statistically significant differences between the control group and the pterygium group (p < 0.001).
<sup>∗∗</sup> Statistically significant differences between presurgery, 10 days and one month after surgery (p < 0.001, Tukey test).

Analysis of corneal biomechanical properties

Corneal biomechanical properties were measured with ORA preoperatively and 10 days and one month after surgery. ORA utilizes a jet of air to deform the cornea and the modifications thus produced are monitored by an electro-optical system. The air jet deforms the cornea generating a first applanation (peak 1) and subsequently a concavity, and after the interruption of the air jet the cornea recovers its original form and passes through a second applanation (peak 2). The CH is calculated as the difference between the pressures measured in mm Hg and those obtained at peaks 1 and 2. The CRF is obtained as a linear function of peaks 1 and 2 on the basis of large scale clinical studies in accordance with the manufacturer. ORA also supplies 2 intraocular pressure measures: Goldmann-corrected intraocular pressure (GIOP), which is the mean of value of pressure peaks 1 and 2, and cIOP which is less affected by corneal properties thus making it a more reliable indicator of true intraocular pressure. All the measurements were taken 4 times and the average thereof was used for statistical analysis.

Statistical analysis

All the data were expressed as mean values and standard deviation (SD). Values of p < 0.05 were taken to be significant. The differences between presurgery and post-surgery data were analyzed by means of the 2-track variance analysis with Tukey’s post-test multiple comparison. The statistical analysis was performed with the SPSS 17.0 for Windows application (SPSS Inc., Chicago, IL).

Results

The studied sample comprised 11 males and 9 females (mean age 45.05, SD 12.06 years, range: 26–68 years). All the patients were Hispanic. All eyes (12 right eyes and 8 left eyes) exhibited primary nasal pterygium. Thirteen pterygium were of grade 1 and seven were of grade 2. No complications were registered during or after surgery throughout the follow-up period.

The presence of pterygium diminished BCVA significantly (p < 0.001) BCVA in comparison with the control group, and

Table 2 – Changes in the biomechanical properties of the cornea before and after pterygium surgery.

<table>
<thead>
<tr>
<th></th>
<th>Control group (n = 19 eyes)</th>
<th>Pterygium group (n = 20 eyes)</th>
<th>p (ANOVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presurgery</td>
<td>10 days postsurgery</td>
<td>One month postsurgery</td>
</tr>
<tr>
<td>CCT ultrasound (μm)</td>
<td>543 SD 25</td>
<td>543 SD 25</td>
<td>543 SD 25</td>
</tr>
<tr>
<td></td>
<td>(514–621)</td>
<td>(511–614)</td>
<td>(511–610)</td>
</tr>
<tr>
<td>CH ORA (mm Hg)</td>
<td>9.52 SD 2.1</td>
<td>9.23 SD 1.73&lt;sup&gt;∗&lt;/sup&gt;</td>
<td>8.05 SD 1.56</td>
</tr>
<tr>
<td></td>
<td>(6.3–13.2)</td>
<td>(5.4–12.1)</td>
<td>(4.1–10)</td>
</tr>
<tr>
<td>CRF ORA (mm Hg)</td>
<td>10.0 SD 2.2</td>
<td>9.67 SD 1.67</td>
<td>9.26 SD 1.67</td>
</tr>
<tr>
<td></td>
<td>(6.9–13.9)</td>
<td>(6.3–12)</td>
<td>(7.1–11.7)</td>
</tr>
<tr>
<td>GIOP ORA (mm Hg)</td>
<td>17.9 SD 6.7</td>
<td>16.38 SD 4.18</td>
<td>18.82 SD 5.94</td>
</tr>
<tr>
<td></td>
<td>(9.3–3.3)</td>
<td>(9.2–24.8)</td>
<td>(9.2–31.1)</td>
</tr>
<tr>
<td>cIOP ORA (mm Hg)</td>
<td>16.6 SD 6.5</td>
<td>17.96 SD 4.46</td>
<td>20.57 SD 5.85</td>
</tr>
<tr>
<td></td>
<td>(7.8–31.9)</td>
<td>(12–26.5)</td>
<td>(12–31.8)</td>
</tr>
</tbody>
</table>

Data are expressed in mean values, standard deviation (SD) and range.
ANOVA: variance analysis; CCT: central corneal thickness; CRF: corneal resistance factor; CH: corneal hysteresis; ORA: ocular response analyzer; cIOP: cornea-compensated intraocular pressure; GIOP: Goldmann-corrected intraocular pressure.

<sup>∗</sup> Statistically significant differences between control group and pterygium group (p < 0.01).
surgical extraction improved BCVA significantly 10 days and one month after surgery in comparison with presurgery values. However, statistically significant changes were not found in refractive parameters or in the presurgery keratometric astigmatism in comparison with the control group and with post-surgery values (Table 1).

Table 2 shows the changes in the biomechanical properties of the cornea before and after pterygium surgery. Statistically significant differences were found (p < 0.01) in CH induced by the presence of pterygium and in comparison with the control group. After 10 days and one month after surgery, CH was reduced in comparison with presurgery values although the changes were not significant. In addition, statistically significant changes were not found in CRF, GIOP, cCIOP or in central corneal thickness (CCT). No significant correlations were observed between presurgery BCVA values and CH.

Discussion

The results of this study indicate that the presence of grades 1 and 2 primary pterygium produced significant modifications (p < 0.01) in the biomechanical properties of the cornea such as CH. In contrast, CH was reduced after surgical extraction of the pterygium with intra-surgery application of 0.02% MMC during 1 min at day 10 and 30 after the surgery although the changes were not statistically significant. Significant changes were not found in CRF or in CCT.

Pterygium, a frequent ophthalmological disease, can produce important changes in the refractive condition and the curvature of the cornea before invading the optic area and cause significant visual defects. Astigmatism secondary to pterygium seems to develop as a result of the traction the pterygium exerts on the apex which involves localized flattening of the central cornea. Larger sized pterygium would be associated to higher astigmatism and greater astigmatic changes after surgery. Recently a significant correlation was found between pterygium size and corneal astigmatism induced after surgery in this study the absence of significant changes in the refractive and keratometric values due to the presence of pterygium and/or pterygium surgery could be explained by the size of the pterygium in the sample, as the pterygium of 65% of patients was grade 1.

The authors were unable to find in the literature studies on corneal biomechanical properties in patients with pterygium. It is known that pterygium can alter the underlying Bowman's membrane by substituting the superficial stroma of the cornea with fibroblasts. Preliminary studies have described that the anterior portion of the stroma makes a greater contribution to corneal resistance than the posterior portion and that the anterior portion is 25% more rigid than the posterior portion. Accordingly, the authors believe that the histopathological changes associated to pterygium could account for the effects it has on the biomechanical properties of the cornea. Patients who underwent photorefractive keratectomy (PRK) and LASIK exhibited modifications in the biomechanical properties of the cornea in relation to the amount of refractive correction, with said changes being greater after LASIK, probably because in PRK Bowman's membrane remains whole and corneal flap

is not made during surgery. In this study the authors did not find statistically significant differences in the biomechanical properties of the cornea after surgery. This discrepancy with results obtained in refractive procedures could be due to the fact that pterygium surgery involves superficial keratectomy and only the epithelium and its basal membrane are removed in the peripheral nasal cornea. Consequently, CH was not modified neither by the superficial keratectomy nor by the intra-surgery application of MMC in our patients with pterygium grades 1 and 2, possibly also because the superficial keratectomy required for the extraction was not very big.

It has been reported that the biomechanical properties of the cornea are unique to each individual. Accordingly, the progression of pterygium toward the cornea could be regulated by its biomechanical properties. Unfortunately the authors did not compare their results with a control group of healthy subjects and therefore it can only be said that the presence of pterygium changes the biomechanical properties of the cornea.

The CH as measured by ORA seems to be an indicator of acquired changes in corneal tissue. CH is significantly lower in patients with keratocone, Fuchs dystrophy, glaucoma and post-LASIK, and significantly higher in eyes of diabetic patients due to the changes that occur in the corneal extracellular matrix as a result of diabetes mellitus. The CH also appears diminished after cataract surgery with clear cornea despite the increase of CCT secondary to corneal edema, suggesting that the incisions could modify the biomechanical properties of the cornea.

By way of conclusion, the results of this study reveal that the presence of primary active pterygium (grades 1 and 2) produces a reduction of the biomechanical properties of the cornea independently from EEC and IOP. Additional studies with longer follow-up times and more advanced pterygium cases and broader keratectomies are necessary to confirm said effects.

Conflict of interests

No conflict of interest has been declared by the authors.

REFERENCES


