Effects of encircling scleral buckling on the morphology and biomechanical properties of the cornea

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Objective: To investigate the effects of encircling scleral buckle (SB) on corneal biomechanical properties of the cornea and its morphological parameters.

Methods: We prospectively examined twelve eyes diagnosed with vitreous haemorrhage undergoing pars plana vitrectomy (PPV), and fifteen eyes undergoing combined PPV and scleral buckle (PPV/SB) for repair of rhegmatogenous retinal detachment (RRD). Corneal biomechanical properties, including corneal hysteresis (CH) and corneal resistance factor (CRF), were measured with an Ocular Response Analyser (ORA) before and 1-month post-operatively. The ORA also determined the values of intraocular pressure (IOP) and corneal compensated IOP (IOPcc). Finally, four morphological parameters of the cornea were measured with the Orbscan II topographer (Orbtek, Inc.): mean corneal power, thinnest corneal point (μm), and anterior chamber depth (ACD).

Results: CH decreased significantly from 10.2 ± 1.7 mmHg to 7.6 ± 1.1 mmHg after PPV/SB (p = 0.003), but not after PPV alone (9.8 ± 3.2 mmHg vs 11.6 ± 2.7 mmHg, p = 0.465). CRF did not change significantly after surgery in both groups. IOPg and IOPcc increased significantly in the PPV/SB group (p = 0.019 and p = 0.010, respectively) but not in PPV group (p = 0.715 and p = 0.273, respectively). Unlike the PPV group, values were significantly higher than IOPg values before (p = 0.001) and after surgery (p = 0.003) in the PPV/SB group IOPcc. Neither the PPV/SB group nor the PPV group showed any significant changes in the corneal morphological parameters after surgery (p > 0.05).

Conclusions: SB surgery leads to a change in the corneal biomechanical properties without altering corneal morphological parameters. It may cause an underestimation error in IOP measurement. PPV may be a less invasive surgical approach for the repair of noncomplex RRD than PPV/SB.

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Efecto del cerclaje escleral en la cirugía vitreo-retiniana sobre la morfología y biomecánica de la córnea

R E S U M E N

Objetivo: Valorar los efectos del cerclaje escleral en cirugía vitreo-retiniana, sobre la biomecánica y morfología del segmento anterior.

Métodos: Estudio prospectivo: 15 ojos con desprendimiento de retina (DR), sometidos a vitrectomía pars plana (VPP) más implante de cerclaje escleral (grupo 1), y 12 ojos con hemorragia vitrea sometidos a VPP aislada (grupo 2). Se compararon pre y postoperatoriamente las propiedades biomecánicas corneales, mediante Ocular Response Analyzer (ORA): histéresis corneal (CH) y factor de resistencia corneal (CRF), además de presión intraocular Goldmann (PIOg) y presión intraocular compensada (PIOcc). Se investigó su relación con 4 parámetros morfológicos obtenidos con Orbscan Ilz: potencia media de K (Mean power), desviación estándar (DE), mínimo espesor corneal (Thinnest) y profundidad de cámara anterior (ACD).

Resultados: CH descendió de 10,2±1,7 mmHg a 7,6±1,1 en el grupo 1 (p=0,003), pero no en el grupo 2 (9,8±3,2 vs 9,6±2,7, p=0,465). No hubo cambios en el CRF tras la cirugía. PIOg y PIOcc aumentaron significativamente en el grupo 1 (p=0,019 y p=0,010 respectivamente), pero no en el grupo 2 (p=0,715 y p=0,273). No hubo cambios significativos en los parámetros topográficos en ambos grupos (p>0,05). Test de Wilcoxon.

Conclusiones: El cerclaje escleral en la cirugía DR no modifica significativamente la morfología del segmento anterior, luego la miopización generada debería exclusivamente a la elongación axial del segmento posterior. La biomecánica corneal si se altera, disminuyendo la CH. Se aporta un argumento más a favor de la VPP aislada en estas cirugías, que supondría una técnica menos agresiva quirúrgicamente.

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Introduction

At present, there is no consensus among vitreoretinal surgeons about the optimum management of regmatogenous retina detachment [RRD]. Surgical management of RRD has evolved greatly in the last 3 decades. Primary pars plana vitrectomy (PPV) is gaining popularity for treating many types of said detachments. It involves potential advantages over conventional surgery with 360° circumferential scleral buckle in cases of detachment without complications, including reduced surgery time, precise diagnostic of small tears, similar reappearance rate with simple surgery and lower rate of complications associated to the use of scleral buckle, including exposure, refractivity changes secondary to axial eye elongation, dioplia, choroidal hemorrhage, diminished blood flow in the retina, the choroids or even the optic nerve and risk of anterior segment ischemia.

The purpose of this study is to research the effects of scleral buckle in the biomechanical properties of the cornea and in its morphology, as well as changes in the intraocular pressure in relation to corneal hysteresis.

Material and methods

Fifteen eyes of 15 patients were selected (8 males and 7 females) in the Ophthalmology Service of the “Lozano Blesa” Clinic Hospital of Zaragoza, who underwent combined vitrectomy surgery with scleral buckle (PPV/SC) due to uncomplicated regmatogenous retina detachment. The mean age of patients was of 61.5±16.8 years (range 23–80). A Mira #240 (Mira, Inc, Waltham, MA, USA) silicone scleral buckle was fitted in all patients. The buckle was sutured to the sclera with reference to the 4 quadrants in situation 13 posterior to the limbus, retromuscular, with a nylon 5–0 monofila-ment (Ethilon). In addition, a Mira # 270 buckle was placed in the inferior temporal quadrant to fix the buckle, with moderate pressure. Subsequently, a 3-way 20-gauge vitrectomy was carried out according to the standard technique with fluid-perfluorocarbon exchange, endolcular laser treatment, followed by fluid-guess exchange with 29% sulfur hexafluoride (SF6).

The control group was made up of 12 eyes of 12 patients (6 males and 6 females) diagnosed with vitreous hemorrhage who underwent 3-way 20-gauge vitrectomy according to the standard technique (PPV). The mean age of patients was of 64.0±1.8 years (range 36–83). The statistical analysis did not reveal significant differences in the mean age of both groups (p=0.755, Mann–Whitney U test).

The surgeries were carried out between March and August 2009 by the same surgeon who is one of the authors (FJA). All the patients exhibited normal corneas in their initial stage on the basis of their history and clinical assessment. Subjects with refractive errors such as myopia >2 dioptres, hypermetropia >1 dioptre or astigmatism >1 dioptre were excluded from the study as well as those with previous ocular surgery, glaucoma, ocular infection, acute or chronic ophthalmological disease, contact lens users or in treatment with any ocular topical medication.
Table 1 – Demographic characteristics in PPV and PPV/SC groups.

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Sex (M/F)</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPV</td>
<td>15</td>
<td>8/7</td>
<td>61.5 ± 16.8(23–80)</td>
</tr>
<tr>
<td>PPV/SC</td>
<td>12</td>
<td>6/6</td>
<td>64.0 ± 1.8(36–83)</td>
</tr>
<tr>
<td>p</td>
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<td>0.755</td>
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</tbody>
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The Ocular Response Analyzer (ORA; Reichert Ophthalmic Instruments, Buffalo, NY, USA) was used to measure corneal hysteresis (CH) and corneal resistance factor (CRF), prior to the operation and one month after surgery with the use of patented applanation two-way dynamic system. An air pulse applies tension on the cornea causing at the formation that is captured by an electro-optical system. The air pulse induces and inward formation followed by an outward deformation when the cornea recovers its original form. This provides 2 applanation measurements. Corneal hysteresis is the result of the difference of these 2 measurements that during the applanation process. The ORA also determines to intra-ocular pressure values, IOPg, equivalent to Goldmann applanation tonometry, and IOPcc, intraocular pressure compensated by the biomechanical properties of the cornea.

The Orbscan I1z topograph (Orbtek, Inc, Bausch & Lomb, Rochester, NY, USA) was used to study corneal morphology. Four parameters were assessed: mean power in the 3 mm optic area (Mean K, in dioptres), standard deviation (SD, in dioptres), thinnest topographic point (Thinnest, in μm) and anterior chamber depth (ACD, in mm).

The study and data gathering were carried out with the approval of the local ethical committee and an informed consent was obtained from all patients who participated in the study.

Statistical data analysis

The data were classified as mean ± standard deviation. For analyzing the age variable and its comparison between groups the nonparametric Mann–Whitney U test was utilized. For comparison in the pre- and post surgery values in each group the Wilcoxon test for independent samples was applied. A value of p < 0.05 was considered to be statistically significant. The data analysis was carried out with the SPSS software version 13.0 (SPSS, Inc, Chicago, IL, USA).

Results

The demographic characteristics of both groups are summarized in Table 1.

Table 2 shows how the mean CH diminished significantly from 10.2 ± 1.7 mmHg to 7.6 ± 1.1 mmHg after PPV/SC (p = 0.003, Wilcoxon test), but not after the independent PPV (9.8 ± 3.2 mmHg vs 11.6 ± 2.7 mmHg, p = 0.465, Wilcoxon test). The CRF did not change significantly after surgery in any of the groups. IOPg and IOPcc increased significantly in the PPV/SC group (p = 0.019 and p = 0.010, respectively), but not in the independent PPV group (p = 0.715 and p = 0.273 respectively). In contrast with the other group, in the PPV/SC group the IOPcc values were significantly higher before (p = 0.01) and after surgery (p = 0.003).

Table 3 shows the corneal morphology parameters measured before and after surgery in both groups. Neither the PPV/SC group nor the independent PPV group exhibited significant changes in these parameters after surgery (p > 0.05).

Discussion

The biophysical factors that contribute to in vivo corneal rigidity and elasticity that maintain its shape are not yet
completely determined. Hysteresis, a parameter that characterizes the biomechanical condition of the cornea, is the result of the ocular counterpressure caused by the combined effect of corneal thickness, ocular rigidity and its biomechanical properties. Some corneal alterations such as Fuchs corneal dystrophy, keratoconus, LASIK, elevated myopia and glaucoma can induce changes in corneal biomechanics with hysteresis reduction.

For the time being, this is the first study that demonstrates that the insertion of a circumferential scleral buckle in vitreoretinal surgery produces an alteration in the biomechanical properties of the cornea. CH was significantly lower in eyes submitted to PPV/SC compared to independent PPV, which means that some aspects of corneal biomechanics have been altered. The length of the ocular circumference is shortened in the place of the buckle implant and the volume of the vitreous cavity diminishes in these surgeries. The mechanism by which the buckle alters the biomechanics is not known. The silicone strip produces a circular indentation in the ocular globe, increasing its axial length accordingly. In addition, it diminishes the ocular pulse amplitude (OPA), and the pulsatile ocular blood flow (POBF) in the eye. Although this reduction is independent of the magnitude of the strip constriction or location, it could be due to venous obstruction or alteration of the long posterior ciliary arteries. This implies that the flow reduction would be more an effect of the restriction of the compliance of the ocular globe. Silver et al. pointed out that the eye in diastole is a sphere full of fluid that must expand to accept the incoming blood during systole. Lencoff et al. suggested that the elastic silicone strip is relatively insensitive to the flow of 1.5 and 2.5 mmHg of the ocular points, which would hinder globe compliance, thus limiting the systolic pulse volume that the eye can admit. It could be expected that if the strip obstructs equatorial expansion, there could be and anterior or posterior offsetting expansion although an OPA reduction in the cornea has been demonstrated which rejects the presence of significant anterior offsetting expansion.

Our findings show that there is no modification in the anterior segment morphology (mean corneal power and standard deviation, thinnest anterior chamber depth), after surgery in the PPV/SC group and the independent PPV group, which is important when assessing for instance the implantation of a phakic lens to correct a refractive defect.

On the other hand, in our study IOPg and IOPcc increased significantly in the PPV/SC group but not in the independent PPV group. Previous studies have demonstrated that Goldman’s application tonometry overestimates intraocular pressure in patients with thick corneas and underestimates intraocular pressure in patients with thin corneas. Biomechanical properties potentially affect the precision of these intraocular pressure measurements. By modifying corneal rigidity, scleral buckle could cause an under estimation of intraocular pressure measurements in post surgery period, with the ensuing delay in the diagnostic of glaucomatous damage.

In summary, more biomechanical and intraocular pressure changes occur in eyes intervened with PPV/SC than in those intervened with PPV on its own. From a mechanical viewpoint, PPV on its own could be a less invasive surgical technique for treating uncomplicated RRD. It is also important to take into account the presence or absence of clinical or subclinical corneal ectasia in patients with RD when planning the surgery because, if ectasia exists scleral buckle would not be indicated as it could worsen it.

In addition, IOPcc is an intraocular pressure measure that has demonstrated to be less affected by corneal properties that Goldman’s application tonometry. It could be useful to improve post surgery IOP follow-up in patients intervened for scleral buckle implant.

Conflict of interests

The authors have no conflict of interests to declare.

REFERENCES