Experimental study of pig dislocated intraocular lens shift after Nd: YAG laser capsulotomy

J. Colomé Campos\textsuperscript{a,b,*}, P. Romero-Aroca\textsuperscript{c}, Ll. Quevedo Junyent\textsuperscript{b,d}, I. Martínez-Salcedo\textsuperscript{e}

\textsuperscript{a} Ph.D. in Medicine, Servicio de Oftalmología, Hospital Comarcal de Mora, Mora d’Ebre, Tarragona, Spain
\textsuperscript{b} Graduate in Optics-Optometrics
\textsuperscript{c} Ph.D. in Medicine, Departamento de Oftalmología, Hospital Universitario San Juan de Reus, Reus, Tarragona, Spain
\textsuperscript{d} Ph.D. in Psychology, Departamento de Contactología, Escuela Universitaria de Óptica de Terrassa, Barcelona, Spain
\textsuperscript{e} Graduate in Medicine, Servicio de Oftalmología, Hospital Comarcal de Mora, Mora d’Ebre, Tarragona, Spain

Abstract

Objectives: To evaluate the movement from their initial set position of subluxated intraocular lenses (IOL) in pig eyes following Nd: YAG laser capsulotomy.

Methods: An extracapsular surgical intervention of the transparent crystalline lens was performed on 15 pig eyes. After the introduction of an intraocular lens into the capsular sac, a zonular dialysis was carried out to observe the shift of the IOL. We carried out a high intensity Nd: YAG laser capsulotomy in a 3.5 mm cross shape in the central optical axis and then measured the final displacement of the IOL using a millimetre ruler.

Results: We did not observe a significant shift of the lens in any of the eyes studied.

Conclusions: Nd: YAG laser capsulotomy is a safe short-term operation for static and subluxated intraocular lenses.

© 2010 Sociedad Española de Oftalmología. Published by Elsevier España, S.L. All rights reserved.

Estudio experimental en ojos de cerdo sobre el desplazamiento de las lentes intraoculares subluxadas tras una capsulotomía láser Nd: YAG

Resumen

Objetivos: Valorar en los ojos del cerdo el desplazamiento de las lentes intraoculares subluxadas respecto a la posición inicial tras la realización de una capsulotomía láser Nd: YAG.

Métodos: Se utilizaron 15 ojos de cerdo a los que se realizó una cirugía extracapsular de cristalino transparente. Tras la introducción de una lente intraocular (LIO) dentro del saco capsular se provocó una diálisis zonular hasta objetivar un desplazamiento de la LIO de un...
valor mínimo de 4 mm. Efectuamos una capsulotomía láser Nd: YAG en forma de cruz en los 3.5 mm centrales del eje óptico a elevadas energías. Se midió el desplazamiento final de la LIO con la ayuda de una regla milimetrada.

Resultados: En ninguno de los ojos estudiados se objetivó un desplazamiento significativo en relación a la situación inicial.

Conclusions: La capsulotomía láser Nd: YAG en LIOs subluxadas se presenta para ojos estáticos como una maniobra segura a corto plazo.

© 2010 Sociedad Española de Oftalmología. Publicado por Elsevier España, S.L. Todos los derechos reservados.

Introduction

Current cataract surgery development is based on 2 ophthalmologists: Ridley,1 in 1949 as the precursor of intraocular lenses, and Kelman2 in 1969 with the design of the first machine for operating with the mini-incision technique. There are many techniques enjoying varying degrees of consensus for cataract surgery, although if there is one thing ophthalmologists can agree on that is that the surgery of choice should be fast, causing the smallest possible trauma and enabling the location of the intraocular lens (IOL) within the capsular sac. This intracapsular positioning assists in maintaining the IOL centered in the absence of inflammatory reaction. The passage of time has shown that this initial location of the IOL within the capsular sac can be dynamic, i.e. it can change in the course of time as a result of an imbalance between the centrifugal and centripetal traction factors that maintain a capsular sac in an initially stable position, with the possibility of causing a small or large displacement of the IOL which, in worst cases, could cause a subluxation thereof derived from the forces generated in the context of capsular fibrosis,3 ocular trauma, degenerative syndromes like pseudoexfoliation or what at present represents the highest number of IOL subluxations, what is known as “late dislocation of the capsular sac–IOL complex”.4

There are several treatments for IOL subluxations, ranging from the most conservative measures focused on following up closely the cases in which we find a patient – generally elderly – who does not exhibit symptoms5 up to surgical treatments consisting in relocating the IOL or removing it and subsequently introducing another lens in the anterior chamber or the ciliary sulcus.

On the other hand, the most frequent complication of cataract surgery which occurs in nearly 50% of the patients in the first 5 years after the intervention is secondary cataracts or posterior capsular opacity.6 This opacity is a consequence of the proliferation and migration of the residual equatorial epithelium of the lens over the posterior capsule, or secondary to fibrous metaplasia, which leads to diminished visual acuity, loss of contrast sensitivity, blinding and on occasions monocular diplopia.7

The technique of choice utilized since 1980 for treating this complication is posterior capsulotomy aided by a neodymium-doped yttrium aluminium garnet (Nd: YAG) laser.8

The problem arises when patients exhibiting a subluxation of the IOL suffer posterior capsular opacification and we decide to perform Nd: YAG laser capsulotomy, because we know that the energy released by this laser is ionic and characterized by transmitting shock and cavitation waves as well as a vibration movement over adjacent tissues or structures – in this case the IOL – which could cause the displacement thereof and in the worst case a severe vision deficit and the need to apply immediate surgical treatment.

We aim at assessing the stability of the capsular sac–IOL complex when these are dislocated after a laser Nd: YAG capsulotomy.

Subjects, material and method

Fifteen fresh eyes of 7-month pigs from a municipal slaughterhouse were utilized. The animals were sacrificed under the rules established by the Helsinki declaration. A few hours postmortem of the corneoscleral cap was trephinated. Subsequently, with the aid of a 26-gauge needle and Uttrata-type pliers, a continuous circular capsulotomy was performed over the lens anterior capsule with a mean value of 4.5–5.5 mm diameter (Fig. 1). After hydroexpression maneuvers with saline, the lens was removed from within the capsular sac, eliminating the resistance cortical remains with a Simcoe-type cannula. The capsules were stained with a dye (Vision Blue® DOCR International bv-Holland), and subsequently we introduced water-repelling acrylic IOL with 17 dioptres, 13 mm total length and 6 mm optic area diameter (Acrysoft SA60 Alcon®) utilizing Kelman–McPherson tweezers inside

Fig. 1 – Continuous circular capsulotomy with a mean diameter of 5.5 mm.
the sac after filling it with a viscoelastic substance (Healon GV Advanced Medical Optics®). After aspiring the viscoelastic, the location and centering was measured against the ocular globe walls with the help of a millimetre ruler and a small mark previously made in the IOL center (Fig. 2). Subsequently and avoiding the appearance of vitreorrhagia, a 220° zonulotomy was made with a 30° scalpel to determine the displacement of the lens vis-à-vis the equatorial plane with a minimum value of 4 mm (Fig. 3).

Finally, a cross-shaped pattern posterior capsulotomy was performed with the technique devised by Hu et al. within the area comprised between the central 3.5 mm of the visual axis with the help of a Nd: YAG (SYL 9000-LightMed Corporation®) laser with high energies (5 mJ and exposure time 0.3 s) (Fig. 4). To end, with a millimetre rule we measured the final IOL displacement against the equatorial plane in relation to the initial coordinates.

Results

The mean number of impacts to achieve capsulotomy was six. Despite the high laser energy values no injuries were perceived in the lens or cavitation.

For all the studied eyes, the initial coordinates for the subluxated IOLs, at no time were they found to be altered despite the high-energy laser treatment. Therefore, no displacements of the capsular sac-IOL complex against the equatorial plane were evidenced.

Discussion

The present study was carried out on young pig eyes. It can be assumed that the remaining non-dialyzed ligaments exhibit full integrity and supposedly higher traction resistance than a human, usually of a certain age exhibiting a degree of deterioration of the ligaments in 360° as indicated by the postmortem ocular stains, mainly in the context of entities that can weaken ligaments, such as the pseudoexfoliative syndrome, the Marfan or Well-Marchesana syndromes, the Ehler Danlos disease or homocistinuria.

Motility was assessed exclusively on the equatorial plane without considering the anteroposterior axis because the pressure gradients of the eyes did not match those of a normal eye. It must be taken into account that the study was made in the absence of cornea, i.e. in “open sky” mode and therefore there was no pressure on the anterior chamber. In addition, the vitreous humor pressure of postmortem eye is underrated due to the ensuing dehydration. Studies carried out on humans have demonstrated that the displacement of a lens vis-à-vis the anteroposterior axis after a small magnitude Nd: YAG laser capsulotomy is not statistically significant in the
first 3 months post-laser.\textsuperscript{11} On the contrary, after large capsulotomies a certain displacement towards the vitreous cavity has been described, in some of these cases involving dislocation above all if the configuration of the implanted lens is of the plate type.\textsuperscript{12,13}

Nd: YAG laser capsulotomy is not free of possible side effects which could occur at the anterior or posterior pole level. However, according to Holladay,\textsuperscript{14} 2.4 mm is the minimum diameter of a posterior capsulotomy to achieve good visual acuity. At present ophthalmologists avoid capsulotomies exceeding 4 mm diameter in order to achieve a considerable reduction of possible complications.\textsuperscript{15}

The present study was performed immediately after Nd: YAG laser capsulotomy. As mentioned above, it must be taken into account that the forces arising within an eye with the passage of time can be degenerative, tractional or gravitational and can also be dynamic, therefore modifying the initial position of a clinical IOL that is subjectively tolerable for the patient.

The current market provides a large variety of IOL designs, dimensions and configurations. We have utilized a single block lens with 2 haptics because we consider that the energy generated by the laser is concentrated in the central area of the impact and is therefore independent of the peripheral tractions that can be generated by the various types of IOL on the periphery of the capsular sac.

Probably the treatment of choice for a dislocated IOL, even more so in a young individual, would be surgical replacement. However, it must be taken into account that not all surgical ophthalmologists are acquainted with this technique, which means that severe complications have been described secondary to said surgery, such as endophthalmitis, vitreous hemorrhage, regmatogenous retina detachment and cystoid macular edema, among others.\textsuperscript{5} Accordingly, the therapeutic indications must be individualized considering that Nd: YAG laser capsulotomy under 4 mm in pig eyes with IOL subluxation is a safe maneuver as it does not evidence complications after Nd:YAG laser capsulotomy under 4 mm diameter in pig eyes with IOL subluxation.\textsuperscript{15}

Conflict of interests

None of the authors have declared any conflict of interests.

**References**