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Case Report

Bilaminar Graft of the Anterior Capsule and Internal Limiting Membrane: A Novel Surgical Technique for the Treatment of Macular Hole and Focal Macular Detachment Associated with High Myopia and Posterior Staphyloma

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Keywords
Macular hole surgery · Anterior capsule graft · ILM graft · Myopic macular hole

Abstract
This case report describes a novel surgical technique for the treatment of macular hole and focal macular detachment associated with high myopia and posterior staphyloma. A 65-year-old female presented with a stage 3C myopic traction maculopathy and VA of 20/600. OCT examination confirmed a macular hole of 958 µm diameter, posterior staphyloma, and macular detachment. We performed combined phacoemulsification surgery with 23G pars plana vitrectomy; the anterior capsule was preserved and divided into two equal circular laminar flaps. We proceeded with central and peripheral vitrectomy, brilliant blue staining, and partial ILM peeling; capsular sheets were introduced sequentially in the vitreous chamber, the first one was implanted below the hole and attached to pigment epithelium, the second lamina was inserted into the hole, and the remaining portion of ILM was implanted crosswise below the edges of the hole. Macular-hole closure and progressive reapplication of the macular detachment were obtained, with a final VA of 20/80. Treatment of macular holes and focal macular detachment in high myopic eyes is complex, even for experienced surgeons. We propose a new technique with additional mechanisms based on anterior lens capsule and internal limiting membrane tissue properties that showed functional and anatomical improvement and could be considered an alternative treatment.

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Introduction

Macular hole in highly myopic eyes with posterior staphyloma (maximum expression of myopic tractional maculopathy), develops on the basis of a pathophysiology, in which,in additionto perpendicular tractional forces exerted by the vitreoretinal interface, the tangential ones, generated by the circumfoveal epiretinal tissue-recognizedcauses of idiopathic macular hole- are added to those resulting from the global expansion of the organ and focal scleral ectasia at the posterior pole, which adds a vector promoting the separation of the neuroepithelium, as well as abiotrophic changes.

This particular condition poses a complex scenario, even for an experienced surgeon. The exceptional axial lengths, the unusual conformation of the vitreoretinal interface, the thinness and friability of the neuroepithelium, the atrophic appearance of the pigment epithelium, and the poor contrast offered by these cases add to the impossibility for the retina to adapt to the remodeling of the scleral wall. This poses trans- and postoperative technical and surgical strategy dilemmas, which haven't found comprehensive answers yet.

External techniques such as macular indentation and internal techniques such as vitrectomy with limitorhexis and flaps of various tissues have been described and used alone or in combination, although their anatomical and functional success rates are clearly lower than those of idiopathic macular holes [1]. It has also been shown that macular indentation has a higher success rate alone or in combination than endoocular techniques [2]. We describe a technical variant of the endoocular procedure, which seeks to take advantage of the therapeutic principles of both techniques, as well as additional ones that result from the properties of the fabrics used and the particular arrangement in which the technique allows their use and interaction.

Case Report/Case Presentation

A 65-year-old female was referred to our center with a single functioning left eye, a right eye with no light perception, with a history of vitrectomy and silicone due to retinal detachment from a macular hole and secondary glaucoma, and nonassessable fundus. Her diagnosis was stage 3C myopic traction maculopathy with a visual acuity of 20/600, eccentric fixation, and a 4-month history of progressive visual decrease . Clinical and tomographic examinations recorded transparent media with an axial length of 30 mm and confirmed the presence of a macular hole of 958 μm, with an estimated area of 0.74 mm^2, posterior staphyloma, and macular detachment confined by areas of external schisis, with a minimum linear diameter of 3,531 μm, estimated by optical coherence tomography (Fig. 1). Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

Surgical Technique

Combined phacoemulsification surgery with an IOL implant and 23G pars plana vitrectomy were performed. The anterior capsule was obtained after continuous circular capsulorhexis (previous trypan blue staining), and then it was divided into two equal parts and two circular laminar flaps around 1.2 mm diameter were configured with retinal scissors. We proceeded with central and peripheral vitrectomy, bright blue staining, and partial ILM peeling, preserving a radial portion of approximately 1 and 1/2 times the diameter of the hole, on the temporal side of the same and adhering to the ridge, withdrawing in the rest of the perimeter. The two capsular sheets were introduced sequentially in the vitreous chamber, and they were placed on the retinal surface regardless of the surface in contact with the retina with ILM forceps; the first one (lower one) was implanted with forceps into the hole and

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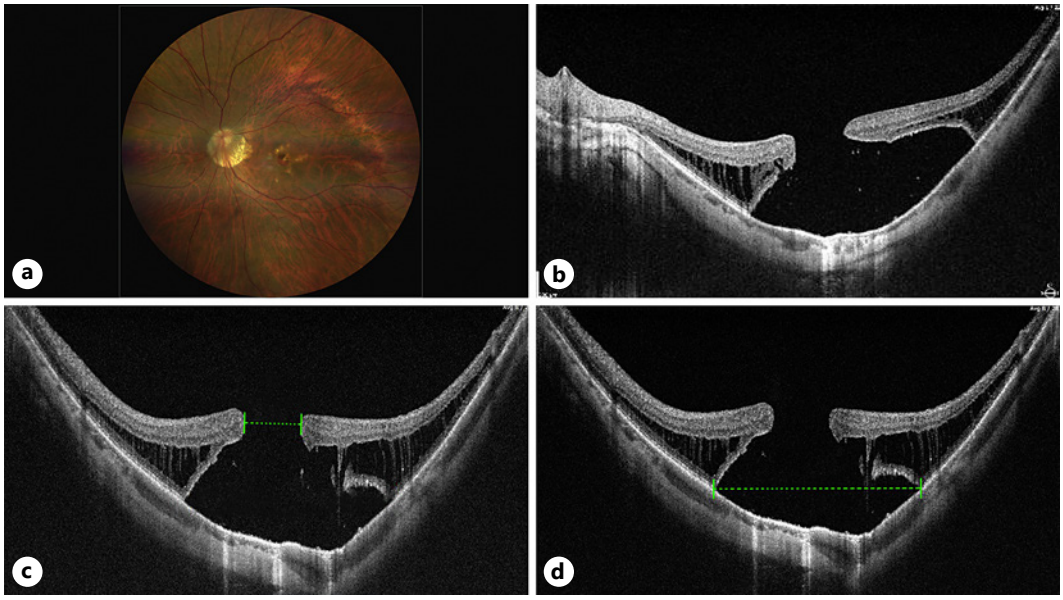

Fig. 1. Clinical case retinography shows a large macular hole and focal retinal detachment around the posterior staphyloma area (**a**). Tomographic image shows myopic tractional maculopathy stage 3C (**b**); large macular hole with a minimum diameter of 968 µm, green dashed line (**c**), and minimal linear base retinal detachment diameter of 3,513 µm, green dashed line, estimated by OCT (**d**).

attached to the pigment epithelium, occupying the space generated by the detachment, and the second lamina (upper one) was inserted into the hole, leaving its redundant edge along the margin of the hole.

The remaining portion of the internal limiting membrane was then lifted and implanted crosswise below the edges of the hole, in the manner of a bar, exerting external displacement and tensioning of the superior capsular sheet because of its greater rigidity, ensuring its position and configuration of an arrangement similar to an hourglass (Fig. 2). The surgery was concluded with air/fluid exchange and 14% perfluoropropane tamponade. Macular-hole closure and progressive reapplication of the macular detachment were obtained, correlating with functional improvement, achieving a better corrected vision of 20/80 after 1 year of follow-up (Fig. 3).

Discussion/Conclusion

The therapeutic principles of the various surgeries proposed for these patients have been based on the elimination of the perpendicular traction vectors at the vitreoretinal-interface level. This is achieved by removal and release of the adhesion of the posterior vitreous cortex, as well as the elements that generate the tangential traction, through the removal of epiretinal fibroglial tissue and internal limiting membrane [3]. These mechanisms include the generation of a tissue scaffold for the growth of reparative tissue through the addition of internal limiting membrane flaps [4, 5], lens capsule [6], amniotic membrane [7], and neurosensory retina transplants [8], as well as compensatory scleral ectasia by volume occupation or opposition (macular indentation) [9]. We conceived and carried out a variant of the endoocular technique, which seeks to not only take advantage of these principles but also to generate additional mechanisms based on the properties of the tissues used and their arrangement.

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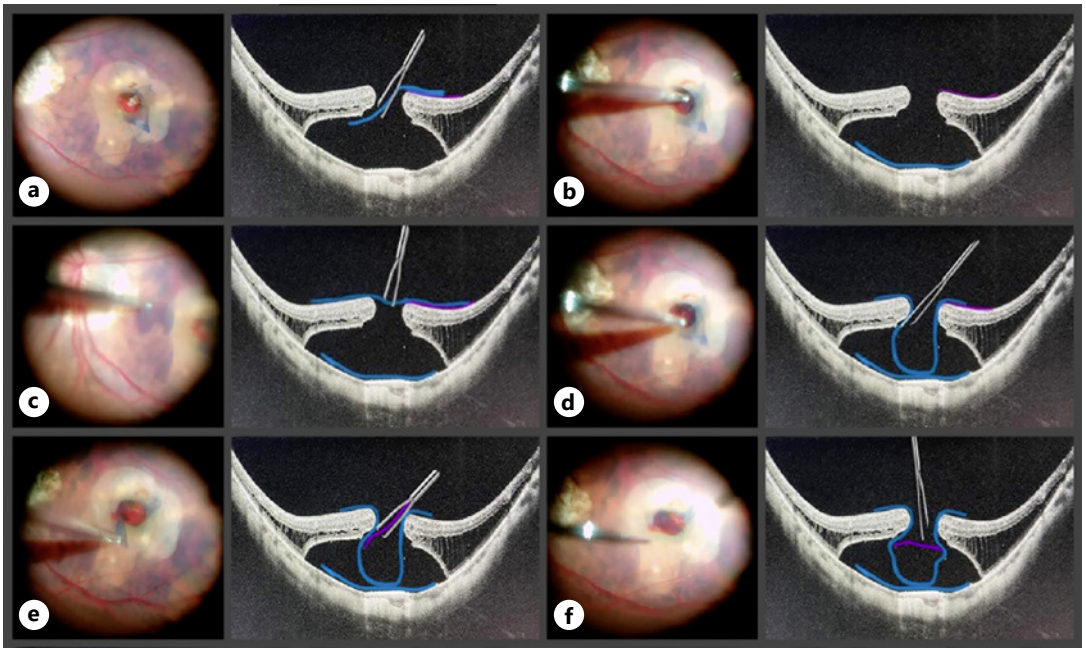

Fig. 2. Surgical technique showing step-by-step positioning of anterior capsule (blue) and internal-limiting-membrane (purple) grafts. Images are represented schematically by OCT images on the right side of each figure. Anterior capsule first graft stuffed into the hole with ILM forceps (**a**, **b**); second lens capsule flap partially placed into the hole, over the first one (**c**, **d**) and ILM-free flap laid into the second capsular flap (**e**, **f**).

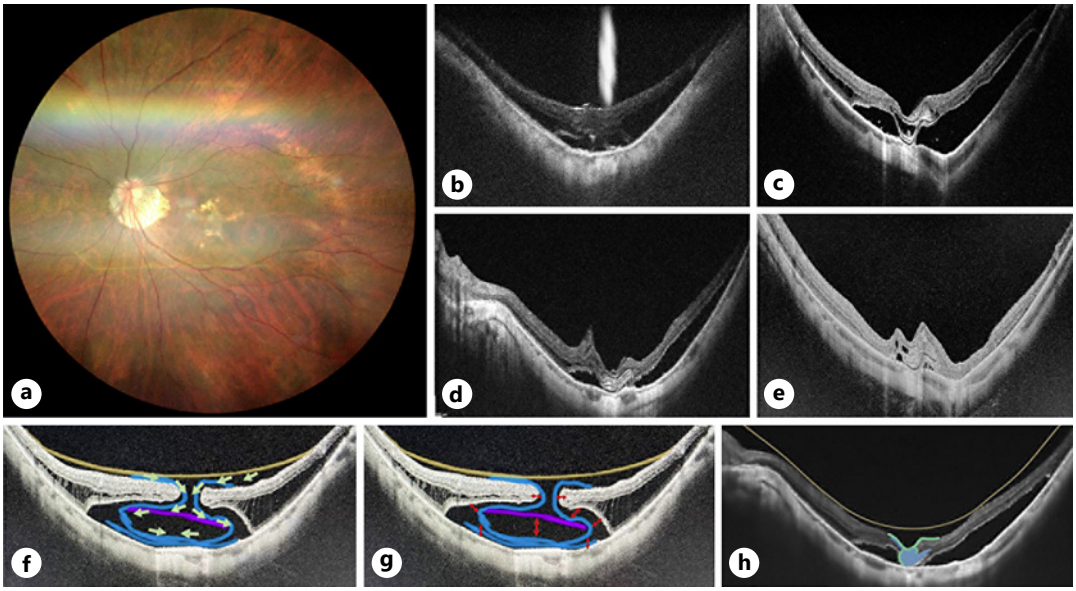

Fig. 3. Postoperative clinical image shows a closed macular hole and reattached retina (a). The tomographic sequence at 1-week (**b**), 3-week (**c**), 12-week (**d**), and 12-month follow-up (**e**), showing macular-hole closure, grafts integration, and gradual retinal reattachment over the staphyloma area. At the bottom, we can observe the schematic OCT sequence of cell migration and proliferation represented with green arrows (**f**), graft adhesion zones in red arrows (**g**), and fibroglial tissue growing highlighted in blue (**h**), all of them allowing the macular-hole closure.

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Both techniques, alone or combined with others, have shown higher anatomic and functional outcomes compared to conventional macular hole surgery, however their primary success rates oscillate around 70%, especially in cases associated to retinal detachment; particularly for endoocular surgery. Therefore, we conceived and innovative technique that pursuits to take advantage of recognized principles, as well as the generation of additional mechanisms, based on tissues properties and disposition. [3, 10]. We chose the anterior capsule of the lens to carry out this technique because of the biological, physical, and biomechanical properties that distinguish it, which include structural support with the provision of epitopes and anchor points for fibrous and epithelial cells, allowing and promoting cell organization, proliferation, migration, and differentiation. Being the thickest basement membrane in the body, it offers great resistance but at the same time selective permeability to intermediate and small molecules, guaranteeing the homeostasis of the subretinal space. Similarly, elasticity, high stress/relaxation index, viscoelastic behavior, and consequent plasticity are ideal for interaction with the limiting membrane of greater rigidity and the high surface tension induced by the gas and finally, the adhesiveness and enhancement of ion pumps [11].

Such qualities take advantage of the disposition of the capsular sheets, which favors cell migration and proliferation along the contours of the hole, not only on the internal surface but also in its entire circumference, providing a strategic redistribution and expansion of the tissue surface available for the development of reparative tissue, which conforms to the shape of the defect. The adhesion between the lower lamina located at the base of the hole with the upper lamina and between the circumferential folds of the upper lamina increased the vectors that promoted the adhesion of the pigment epithelium to the neuroepithelium, both perpendicular and centripetal, while generating volumetric compensation of the space generated by the focal ectasia. The insertion of a portion of the internal limiting membrane, in the manner of a bar with a greater diameter than the hole below its margins, ensures the position of the upper capsular sheet, as well as the expansion of its edges below the edges of the hole given its greater rigidity. It is under these circumstances and the surface tension induced by the long-lasting gaseous tamponade that compaction, closure, and cell filling processes are completed, with the consequent structural benefit.

In contrast, it is important to remember that there is still controversy regarding the convenience of inserting the tissue into the hole, due to the possibility that this could interfere with its closure or worsen the final visual acuity; however, evidence has shown that in the case of idiopathic macular holes, both techniques reached the same anatomical and functional outcomes, including remodeling of the foveal shape and external retinal layers restructuring (ellipsoid zone and external limiting membrane) [12] and additionally, reducing the probability of graft displacement. Also, regarding the myopic macular hole, the ILM flap could contribute to preventing retinal redetachment [13].

We believe that the development of new techniques and rethinking of surgical strategies, in the context of this complex pathology, should respond not only to the identification and understanding of the pathophysiological mechanisms involved, making it possible to counteract them, but also to the recognition of scaffold tissues properties and possible interactions between them, in order to enhance their advantages and therefore improve therapeutic effects.

Statement of Ethics

Written informed consent was obtained from our patient for publication of the details of this medical case and any accompanying images. This study was reviewed and approved by our institutional Ethics Committee – Comité de ética Clínica del Ojo. Internal code: 2021JFC51MS.

Conflict of Interest Statement

No conflicting relationship exists for any author.

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No funding was provided for this study.

Author Contributions

Sergio A. Murillo: design of the work, surgical technique, analysis, and interpretation of results. Rosa Maria Romero: writing process, translation, and interpretation of results. Silvia P. Medina: data and image acquisition, figures elaboration, and analysis of results.

Data Availability Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

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