

# Equine pericardium for tectonic globe repair

Konstantinos Droutsas · Dimitrios Papaconstantinou · Ilias Georgalas ·  
Georgios Kymionis · Konstantinos Andreanos · Elli Stamou · Nikolaos Mamas

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## Abstract

**Purpose** To describe the use of equine pericardium as an off-label temporary emergency treatment of scleral and corneal perforations.

**Methods** Three eyes of two male patients aged 34 and 38 years were included, i.e. a case with a history of severe bilateral thermal burn undergoing phacoemulsification complicated by tearing of the main port causing iris exposure and a patient with bilateral corneal perforation secondary to non-infectious corneal melt due to presumed ocular non-steroid anti-inflammatory drug abuse. The equine pericardium patch was soaked in balanced salt solution, trimmed and sutured over the perforated area with interrupted nylon 10-0 sutures. Slit-lamp photographs were taken before and immediately after surgery as well as at 2 and 5 months postoperatively.

**Results** A watertight closure of the perforation was achieved in both cases. No evidence of infection, severe inflammation, leakage or hypotony was detected throughout the observation period. The first patient developed a pseudopterygium over the pericardium patch 5 months after surgery. The second patient showed at 2 months a bilateral melt of the pericardium and loosening of the sutures. After removal of the latter, a tectonically stable scar was evident in both eyes.

**Conclusion** Equine pericardium offered an effective primary treatment in cases of non-infectious globe perforation and may be considered when other materials, e.g. amniotic membrane, corneal or scleral allografts, are not readily available. Further studies may further elucidate the safety and efficacy profile of this biomaterial in ophthalmic surgery.

**Keywords** Lyophilized equine pericardium · Globe perforation · Tectonic patch

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K. Droutsas · D. Papaconstantinou · I. Georgalas ·  
G. Kymionis · K. Andreanos · E. Stamou · N. Mamas  
First Department of Ophthalmology, National and  
Kapodistrian University of Athens, 11527 Athens, Greece

K. Droutsas  
Department of Ophthalmology, Philipps University,  
35043 Marburg, Germany

K. Droutsas (✉)  
First Department of Ophthalmology, National and  
Kapodistrian University of Athens, Mesogeion Ave 154,  
15667 Athens, Greece  
e-mail: konstantinos\_droutsas@yahoo.gr

## Introduction

Corneal perforation is an ophthalmological emergency as it may cause devastating acute complications, which in the longer term can lead to blindness and phthisis. Prompt recognition and immediate closure of the perforation are therefore crucial in order to maintain globe integrity [1].

Smaller corneal perforations may be treated with a bandage contact lens, cyanoacrylate tissue adhesives, conjunctival flaps or amniotic membrane transplantation, while larger perforations may require patching with more stable materials, such as scleral and corneal allografts [1].

Scleral or corneal allografts are in many countries not readily available; hence, alternative biomaterials with similar properties (high mechanical resistance, biocompatibility) may be considered when facing emergencies [2].

Processed bovine, as well as human donor pericardium, is a collagenous membrane with high mechanical stability that has been applied in ophthalmic surgery for managing exposed glaucoma shunts [3–5], orbital implant exposure [6, 7] as well as scleral thinning [8]. Recently, the successful use of bovine pericardium for patching corneal perforations was reported [9, 10]. However, both bovine and human donor pericardium carry a theoretical risk of prion transmission; therefore, grafts from other species offer an advantage with regard to this issue.

Equine pericardium is a novel biomaterial that has been applied as a patch in various surgical fields, e.g. as a dura substitute in neurosurgery [11], for reconstruction of calcified mitral annulus and aortic aneurysms in cardiovascular surgery [12, 13] and for treating bone defects in dental surgery [14, 15]. Despite its widespread use in these specialties, the use of equine pericardium has not been reported in ophthalmic surgery up to date. Herein the use of equine pericardium for the emergency management of corneal perforations is described.

## Case report

Tectonic patching with use of equine pericardium (Lyomesh Neuro VR, LYO-040 X 050 H, Audio Technologies S.r.l, Gossolengo-Placenza, Italy) in two patients (3 eyes) with non-infectious globe perforation is herein reported. Equine pericardium was used in an off-label manner. Informed consent was obtained from both patients prior to surgery.

### Patient 1

A 34-year-old man with a history of bilateral penetrating keratoplasty (PK) and multiple eyelid and

conjunctival surgeries following severe thermal burn with liquid aluminium underwent phacoemulsification on his right eye for intumescent cataract causing phacogenic pupillary block. In the presence of a thinned and brittle sclera following severe thermal injury, the main incision extended irregularly to an approximate diameter of 3 mm, causing iris exposure.

While primary suturing allowed sufficient adaptation of the tissue intraoperatively, loosening of the brittle corneoscleral tissue and cheesewiring of the sutures led to a gradual enlargement of the defect with iris exposure in the following 2 days (Fig. 1a). Therefore, after carefully debriding the conjunctival epithelium, two layers of lyophilized equine pericardium were fixated over the defect using multiple interrupted nylon 10-0 sutures (Fig. 1b).

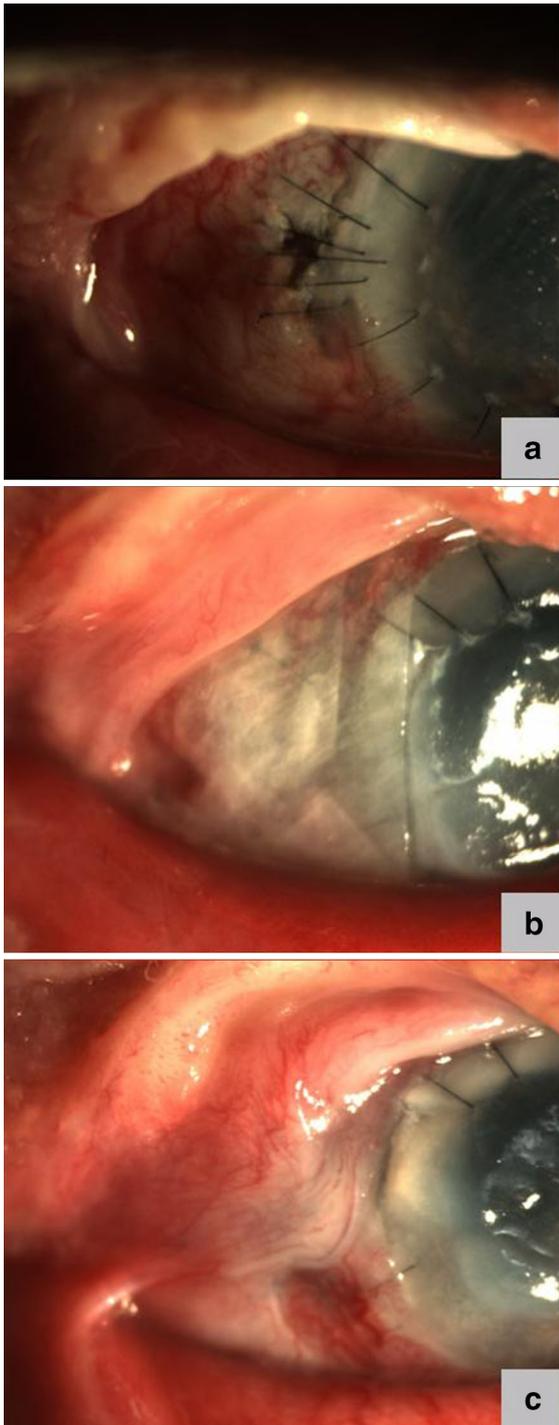
### Patient 2

A 38-year-old man was referred with bilateral perforated corneal melt due to presumed ocular non-steroid anti-inflammatory drug (NSAID) abuse. Biomicroscopy showed bilateral melting of the inferior half of the cornea with focal perforation of approximately 4 mm, iris prolapse and athalamia (Fig. 2a, b). A single layer of equine pericardium was fixated over each perforation with interrupted nylon 10-0 sutures (Fig. 2c, d).

### Technique

In all 3 cases, suturing was performed under topical anaesthesia. According to the manufacturer's recommendations, the dry patch was immersed in physiological saline solution for 1 min to soften and recover its original consistency. After debriding the necrotic tissue, the extent of the defect was measured and the pericardium sheet (40 mm × 50 mm) was trimmed to the appropriate size and shape and sutured with interrupted 10-0 nylon sutures. Finally, cefuroxime at a concentration of 1 mg/0.1 ml was injected into the anterior chamber.

During the postoperative period, oral and local antibiotic as well as local anti-inflammatory treatment was given. Both patients were examined on a daily basis for signs of infection or hypotony, while the intraocular pressure was carefully estimated digitally.



**Fig. 1** Photograph collage of slit-lamp pictures of the right eye of patient 1. Primary closure of the scleral defect was not feasible due to excessive brittleness of the sclera 1 year after a severe thermal burn and multiple surgeries of the eyelids and ocular surface (a), successful sealing of the defect with two layers of lyophilized equine pericardium (b), establishment of a hypertrophic scar within 5 months after surgery (c)

an observation period of 6 months with no evidence of infection or recurrent melting. Intraocular pressure remained stable and the patients did not complain about pain or significant discomfort.

The first patient developed a hypertrophic vascularized scar covering the pericardium at 2 and 5 months after surgery (Fig. 1c).

A self-limiting partial melt of the pericardium and loosening of sutures was observed at 2 months in both eyes of the second patient (Fig. 2e, f). During removal of the sutures, the pericardium dislodged exposing tectonically stable vascularized scars (Fig. 2g, h).

## Discussion

The successful employment of lyophilized equine pericardium for sealing non-infectious corneal perforations is reported. This is to our knowledge the first report on the use of this reconstructive biomaterial in ophthalmic surgery.

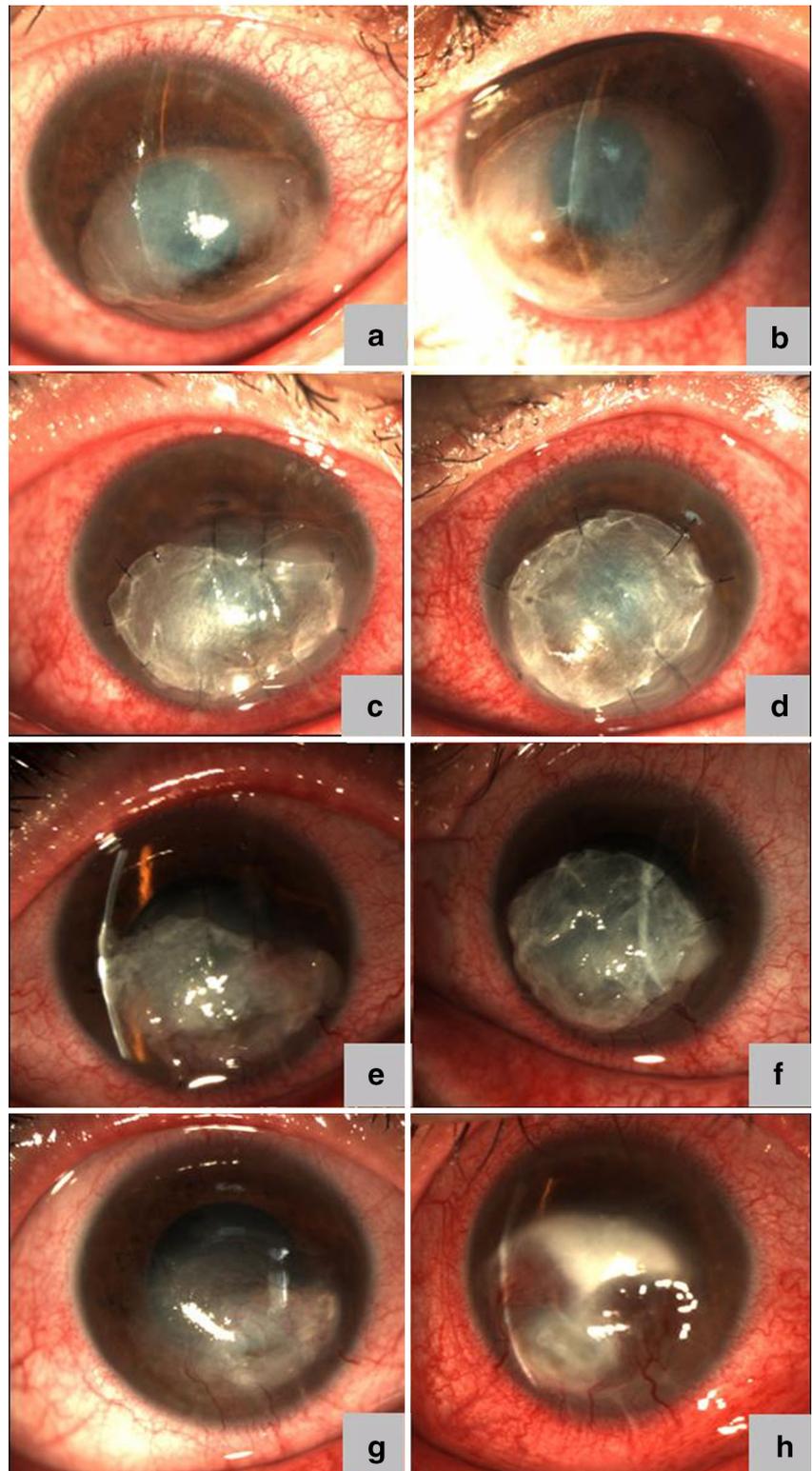
Lyomesh Neuro VR is industrially processed equine pericardium. As described by the manufacturer, the cellular components of the tissue are removed through an enzymatic process resulting in an antigenically neutral biomaterial. The purified collagen network is then chemically sterilized and finally irradiated with  $\beta$ -rays [16].

This compacting and lyophilization process (freeze drying) offers characteristics that render the pericardium suitable for sealing tissue defects. (1) It becomes easy to handle and its transparency allows visibility of the underlying tissues (Fig. 1a–d). (2) The collagen network has a high mechanical resistance. (3) Due to its equine origin, there is no risk of prion transmission. (4) It is considered as biocompatible and is not expected to show any toxicity, mutagenicity or hypersensitivity reaction [16]. All these qualities render lyophilized equine pericardium a reasonable

## Outcome

In all 3 cases, immediate watertight closure of the globe defect was achieved and maintained throughout

**Fig. 2** Photograph collage of slit-lamp pictures of both eyes of patient 2. Please note the perforated corneal melt causing iris prolapse and athalamia in the right (OD) (a) and left eye (OS) (b), the single layer of equine pericardium fixated with nylon 10-0 sutures OD (c) and OS (d), a partial melt of the pericardium at 2 months OD (e) and OS (f) and finally a tectonically stable vascularized scar 5 months after surgery OD (g) and OS (h)



off-label choice for scleral or corneal sealing, when donor grafts are not readily available.

First-line choices for tectonic globe repair include gluing, conjunctival flaps, amniotic membrane and corneal transplantation in the form of penetrating keratoplasty, corneal patch graft, lamellar keratoplasty or tectonic epikeratoplasty [1] as well as human donor sclera [17].

In both cases, the extent of the perforation (>3 mm) as well as the instability of the surrounding tissues (brittle sclera after severe burn in patient 1 and cornea melt in patient 2) did not allow application of cyanoacrylate adhesive as this is indicated for smaller defects [18–20]. In addition, preparation of a conjunctival flap was not possible due to excessive conjunctival scarring secondary to severe thermal burn in patient 1. Moreover, conjunctival flaps are not indicated for active keratitis with severe stromal thinning or in cases of a frank perforation, as they cannot always control the leakage [21].

Amniotic membrane, corneal and scleral allografts are established biomaterials for sealing ocular surface defects; however, they were not available at that point in our clinic.

Overall, equine pericardium patch was shown to be effective for sealing both scleral and corneal perforations. In the case of scleral perforation, a fibrotic scar covered the pericardium a few weeks after surgery, unfortunately further compromising the ocular surface. Considering the complicated history of thermal burn and multiple previous surgeries, extensive scarring could be attributed to a severe stem cell deficiency rather than the pericardium overlay itself [22]. However, future research could supply evidence with regard to this issue.

In the case of bilateral corneal melt, a significant superficial and deep corneal neovascularization at the area of the pericardium graft especially on the left eye was established between the second and fifth month of follow-up. Since host bed vascularity is a cardinal risk factor for corneal graft rejection [23], further management of neovascularization is essential for a good outcome after keratoplasty.

To conclude, this is the first report on the use of equine pericardium for sealing scleral and corneal defects. Globe integrity was achieved and retained in all three cases with no signs of aqueous leak, hypotony, infection or recurrence. Considering its easy access and safety, it may be considered for the

urgent management of scleral or corneal perforation when other donor tissue is not available.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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