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REVIEW

Chromovitrectomy

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Abstract

The term "chromovitrectomy" has been coined to define the use of vital dyes in vitreoretinal surgery. The basic concept for the application of vital dyes during vitreoretinal surgery is to assist in highlighting preretinal membranes and tissues which are very thin and semitransparent and thus difficult to detect. Various dyes are currently being used in routine clinical procedures, however, the ideal staining agent has not yet been found. The vital dyes indocyanine green, infracyanine green, and brilliant blue stain the internal limiting membrane, trypan blue and triamcinolone acetonide help to visualize the epiretinal and vitreous membranes. New dyes with a better safety profile than the synthetic ones are important for optimizing the outcome of modern ophthalmic surgery and natural dyes, such as lutein, offer a potentially safer and more efficient method of identifying intraocular structures such as vitreous and ILM. Any dye, which is intravitreally injected has the potential to become toxic.

Keywords: chromovitrectomy, internal limiting membrane, epiretinal membrane, triamcinolone acetonide, indocyanine green, infracyanine green, brilliant blue, lutein-based dyes

Definition

"Chromovitrectomy" is a term used for describing the vital dyes use during vitreoretinal surgery to assist in the identification of preretinal tissues and membranes.

Technique for applying the dye during vitrectomy

Various techniques for staining the vitreous cavity with vital dyes have been described. One is the so-called "dry technique" which is carried out with the eye full of air after removing the liquid from the vitreous cavity followed by a liquid-gas exchange before injecting the dye. The advantage of this procedure is a higher concentration of dye over the retina and avoiding contact with the lens, against the disadvantage of inducing possible retinal toxicity due to its high concentration.

The second procedure is the so-called "wet method", carried out with the eye full of liquid while the dye is injected over the retinal surface. In these cases, the dye concentration is lower because it is diluted in the vitreous cavity fluid, the drawback being that the dye could disperse and stain other retinal areas or the posterior lens [1,2].

Types of vital dyes

Vital staining refers to the coloration of living cells or tissues. Dyes are organic molecules containing chromophores. A chromophore is the part of a molecule responsible for its color. The ideal vital dyes should have a safety profile for intraocular use, the ability to reliably and selectively stain the intraocular membranes. Some of the other characteristics are rapid elimination from vitreous cavity and an adequate light absorption profile. However, the ideal staining agent has not yet been found and any dye, which is injected intravitreally, has the potential to become toxic.

Indocyanine green (ICG)

ICG is a hydrophilic dye used for angiography because of its properties as a fluorophore also acting as a chromophore, staining the ILM green because of its affinity to laminin and collagen type IV within the ILM [3]. Indocyanine green was first reported to stain the anterior capsule of the lens for the capsulorhexis and now it is the most potent and specific ILM stain used in macular hole surgery [4].

Fig. 1 Injection of ICG in low concentration and directed to the macular prevents the staining of the retina elsewhere, and minimizes the amount of dye left intravitreous

Chromovitrectomy using ICG for dye assisted peeling of ILM gained acceptance for the management of macular holes [5,6]. Its use was later extended to improve the visualization of the glial ERM, proliferative membranes of proliferative diabetic retinopathy and proliferative vitreoretinopathy. Controversial reports on the toxic effects of ICG have been published. These included Muller cell, RPE and ganglion cell damage; visual field defects and optic atrophy [7].

Infracyanine Green (IfCG)

Good anatomic and visual results have been obtained after IfCG-assisted ILM peeling in macular holes and diabetic macular edema cases. IfGG seems to offer a safer profile for chromovitrectomy than IGC. In addition, it allows the identification if ILM at a concentration of 0.5 mg/ ml with less toxic effects.

Triamcinolone Acetonide (TA)

Triamcinolone acetonide (TA) is a well-tolerated corticosteroid used for the local treatment of several ocular diseases, such as ocular inflammation, macular edema and age related-macular degeneration. The white steroid suspension has been used for chromovitrectomy since 2003 to visualize the transparent vitreous gel and the posterior vitreous cortex [8]. The surgical technique for the TA application consists of a direct injection of the agent into the vitreous cavity where its particles adhere to the vitreous gel facilitating visualization and identification.

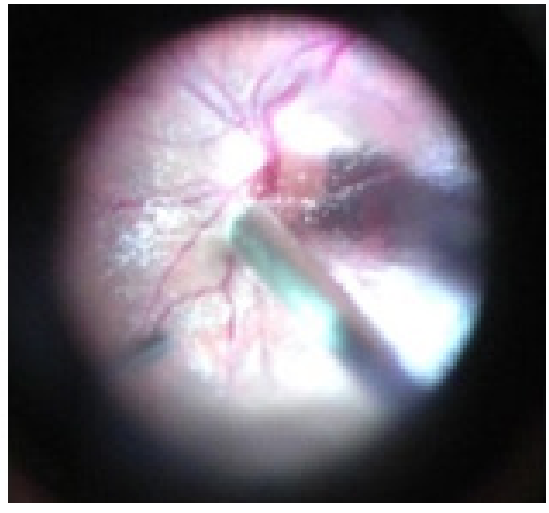

Fig. 2 Triamcinolone acetonide particles adhere to the vitreous gel making its visualization and identification easy

Currently, this is the most widely used technique to visualize the posterior hyaloid. A comparative study of fluorescein, ICG, TA and TB concluded that the vitreous was best highlighted by TA [9].

Trypan Blue (TB)

Trypan blue is a vital stain used in surgery for the removal of epiretinal membranes and for staining the anterior lens capsule during cataract surgery. Most studies observed the absence of toxicity for the retina and the RPE, although one case was reported in which the dye migrated to the sub-retinal space, producing changes in the RPE without visual repercussions [10].

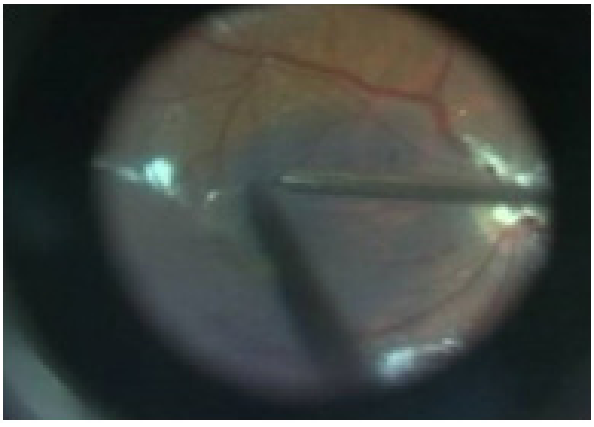

Fig. 3 Intraoperative photograph of an epiretinal membrane stained with trypan blue

Brilliant Blue G (BBG)

Brilliant Blue G provides selective staining of the ILM. It was approved in the European Union in 2007 as Brilliant peel (Fluoron/ Geuder, Heidelberg, Germany). After intravitreal BBG, no toxic effects of BBG, such as corneal edema, severe retinal edema, or endophthalmitis were observed by surgical microscopy over a period of two months. The normal structure of the retina was preserved in eyes injected with high doses of BBG (10mg/ ml) with no infiltration of inflammatory cells being observed.

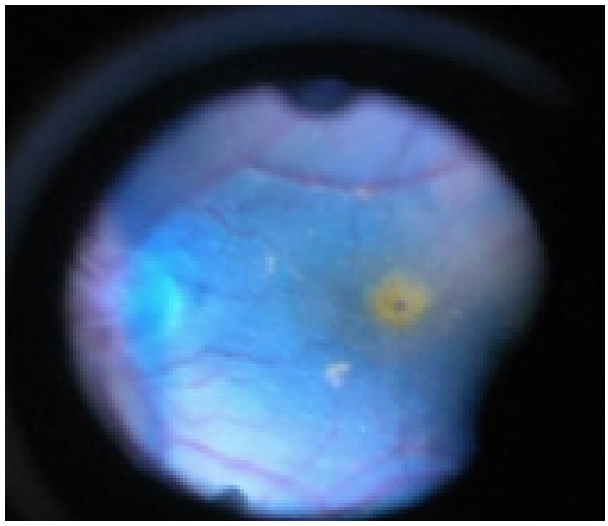

Fig. 4 Intraoperative photograph of brilliant blue G staining of the internal limiting membrane in an eye with idiopathic macular hole

Lutein-based dyes

Lutein and zeaxanthin (L/ Z) are lipophilic pigments belonging to the group of carotenoids and have been identified as the major components of the macular pigment. In vivo and in vitro trials have been made to analyze the specific action of L/ Z alone or in combination with other vital dyes, to evaluate cytotoxic events and structural alterations [11]. The results demonstrated that the natural dye solutions based on L/ Z have a safe profile in cell culture and animal models, and may be a useful tool for intraocular structure staining during phacoemulsification and vitreoretinal surgery.

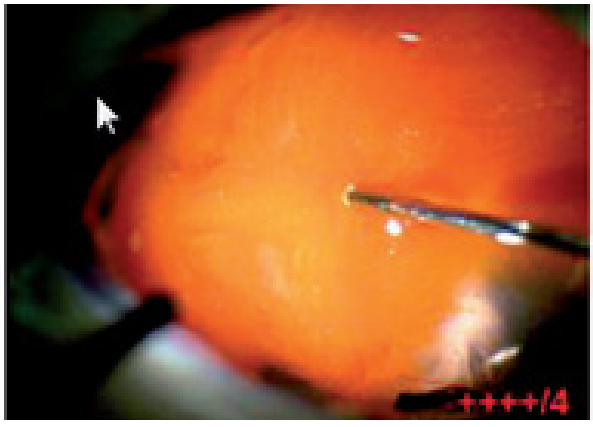

Fig. 5 Vitreous staining with 20% solution of lutein onto the retinal surface. Lutein crystals are deposited in the vitreous and induce a strong orange staining

Other studies described the use of novel intraocular dyes, in which Lutein is the primary component in cataract and vitreoretinal surgeries [12,13]. These L/ Z-based dyes have shown efficacy in staining target membranes such as the anterior capsule, ILM, and the vitreous, as well as an excellent safety profile [12]. These results suggest a nonchemical bonding to the membrane and are in agreement with previous preclinical and clinical tests, which showed that this natural dye is safe to be used intraocularly [14,15].

In conclusion, this study demonstrates that lutein-based dyes can interact with different membrane models of structures present in the human eye.

Advantages and disadvantages

Some of the advantages of using vital dyes include only a small amount of dye which is required, it is easy to inject and easy to remove, the dye needs to stay in the eye for only a short duration of time, there is minimal penetration of the dye into the retinal tissues and it can be placed selectively above the zone that will be peeled.

On the other hand, toxicity represents one of the possible disadvantages of using vital dyes. The toxic effects of any vital dye depends on its concentration, dye exposure time, the osmolarity of the solution, and illumination time. To avoid toxicity, a number of recommendations should be considered: lowest concentration that will achieve staining should be used and dilutions with physiological osmolarities must be rigorously attained.

Conclusion

The intraoperative application of vital dyes for the visualization of intraocular membranes and tissues has facilitated surgical techniques and outcomes in recent years.

ICG has been the "pioneer dye" for ILM-peeling, alternatives to ICG being IfCG and brilliant blue. For ERM removal, the current preference is trypan blue and triamcinolone acetonide is preferred for vitreous visualization.

New dyes with a better safety profile than synthetic dyes are important for optimizing the outcome of modern ophthalmic surgery and natural dyes such as lutein offer a potentially safer and more efficacious method of identifying intraocular structures such as anterior capsule and ILM.

The future goals of chromovitrectomy include choroidal neovascular membranes, prematurity retinopathy, proliferative vitreoretinopathy, and intra-ocular tumors.

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