Novel material to quantify sharpness and traction of vitreous cutters

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Received: 07 Dec 2010
Accepted: 22 Apr 2011
Published: 15 May 2011


Abstract

There is no available method for evaluating cutting quality of vitreotomes. The available methods of assessment allow only indirect judgment of their quality and are difficult to apply in clinical practice. We propose using a collagen film with maximum thickness of 1-2 micron to test the sharpness of instruments under conditions resembling clinical ones. The collagen film is fixed by a special device, then placed in physiological saline, and then cut under the operation microscope. It shows whether the cutting edges are sharp enough, and the collagen film is cut smoothly. We also use an Electroforce 3100 machine and Dynamic Mechanical Analysis software to quantify the vitreoretinal force applied to the retina during vitrectomy.

Keywords
Vitreectomy, Vitreous cutter, Retinal traction, Collagen film

Introduction

Advancements to the instruments used for the vitrectomy procedure have been driven, at least in part, by the need for greater functionality and improved safety. [1] Modern vitreous cutters operate at higher cut rates and aspiration levels than their earlier versions, using suction and inclusive shearing. Today’s surgeons have a number of different types of cutters to choose from when performing minimally invasive vitrectomy procedures. Effective management is based on recognizing and addressing different factors in each surgical case. [2]

Vitrectomy has evolved dramatically over the past 4 decades, as research has led to an enhanced understanding of its benefits for many diseases. [3] Current innovations suggested by manufacturers to permit faster and safer surgery are largely subjective assertions. Better lighting, improved optics, new adjuvant agents, increased fluidics control, or a combination of these may enhance surgical skills. [4]

Teixeira et al report a novel method to quantify traction applied to the retina using vitreous cutters during pars plana vitrectomy. In their method, fresh porcine eyes were positioned in a specially develop-
oped holder and transfixed to the retinal layers with a wire and the other end fixed to the load cell of a strain gauge. Electrical drive mechanism vitrectors were introduced into the eye and positioned at a distance of either 3 or 5 mm from the retina. They found traction was directly proportional to the aspiration vacuum and inversely proportional to the cut rate. [1]

**The Hypotheses**

We would like to share our hypotheses to evaluate the sharpness of vitreous cutters which can be used as a new material instead of fresh porcine eyes to quantify traction applied to the retina. We propose using a collagen film with maximum thickness of 1-2 micron to test the sharpness of instruments under conditions resembling clinical ones [Figure 1]. Regarding to the animal ethical issue which states that if an alternative method exists, it would partly or wholly replace the use of animals in a project, the use of collagen film instead of fresh porcine eyes which is transfixed with a wire as an alternative to quantify traction applied to the retina is acceptable in experimental research.

**Evaluation of Hypotheses**

Collagen film with maximum thickness of 1-2 micron, will be fixed by a special device, then place in physiological saline, and then cut under the operation microscope. It will show whether the cutting edges are sharp enough, and the collagen film is cut smoothly. We also use an Electroforce 3100 machine and dynamic mechanical analysis software to quantify the vitreoretinal force applied to the retina during vitrectomy and compare the results of our proposed material with Teixeira et al. report.

**Discussion**

Since the closed-eye pars plana vitrectomy (PPV) was first performed in the 1970s, quantifying the traction applied to the retina by different vitreous cutters has always presented a challenge for engineers and surgeons. Over the years, vitreous cutters have become smaller, faster, and safer, with higher cut rates, but the need to develop a cutter that works with the least amount of suction force required to safely shear the tissue while creating the least possible amount of traction made it necessary to measure the vitreoretinal force created by the actual cutters. [1, 5]

During cutting, a vitreous fragment can be attached to the residual vitreous block and sometimes to the retina. When the port opens, the cutter aspirates a portion of the vitreous block, causing traction on the surrounding tissue, which is the real traction that can cause retinal tears. An ideal cutter would cause less traumatic vitreous removal, leading to decreased force on the surface of the residual vitreous block surface. [4]

Vitreous cutters must be sufficiently sharp and have a high cutting quality, because these factors allow smooth cutting of vitreous fibres without retinal traction. If the cutting part of the vitreotome tip is not sufficiently sharp, severe complications may develop during intravitreous interventions. It is particularly true for the rotatory types in which vitreous fibres may be wound around the working part of the vitreotome rather than cut off, which may lead to retinal detachment.

The adequate sharpness of the cutting part of vitreotomes is guaranteed by making them of hard high-quality stainless steel and polishing them. However, the cutting efficiency depends not only on the sharpness but also on the adjustment of the cutting surfaces. It is very important that there is no gap between the cutting edges. Otherwise, cutting of vitreous fibres during vitrectomy will be incomplete, which can cause the development of tractions on the retina.

Despite the technical improvements in the existing vitreotomes and the appearance of new models of instruments for vitreous removal [6, 7], Our preliminary measurements (Ghaffariyeh et al unpublished data) have shown that the primary determining factors are the sharpness of the cutting edges and the quality of vitreous synechiae incision; all other functions (vacuum, cut velocity, and gauge) [8] of these instruments are secondary importance. It is technically very difficult to obtain ideal cutting edges in metal tips, so we think in future vitreotomes; the cutting edges will be made of hard crystals, which will make it possible to improve the sharpness of the vitreotomes and the quality of cutting to the ideal level based on the mechanical principal.

The quality of the cutting parts of these instruments should be monitored constantly by a surgeon, and they should be checked prior to each operation. However, the available methods of assessment allow only indirect judgment of their quality and Teixeira et al method is difficult to apply in clinical practice so this new idea is simple and cheap method to test cutter quality.

**Acknowledgements**

We gratefully acknowledge Rosha and Kashayar Ghaffariyeh for their kind cooperation. None of the authors have any financial or proprietary interest in any material or method mentioned. There is no financial relationship with these centers.
Overview Box

First Question: What do we already know about the subject?
There are no available methods for evaluating the cutting properties of vitreotomes. The available methods of assessment allow only indirect judgment of their quality.

Second Question: What does your proposed theory add to the current knowledge available, and what benefits does it have?
We propose using a collagen film with maximum thickness of 1-2 micron to test the sharpness of instruments under conditions resembling clinical ones.

Third question: Among numerous available studies, what special further study is proposed for testing the idea?
Collagen film with maximum thickness of 1-2 micron, will be fixed by a special device, then place in physiological saline, and then cut under the operation microscope. It will show whether the cutting edges are sharp enough, and the collagen film is cut smoothly.

Figure 1. Schematic model of special device, wire, and instrumentation used to quantify the vitreoretinal traction
References


