MULTISTAGE CUTTING OPTHALMIC DEVICE

TEAM 46

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OVERVIEW

FIELD OF THE INVENTION

The invention pertains to an instrument designed for use in ophthalmic surgeries, such as vitrectomy. It is a mechatronic vitrectomy handpiece that is portable, fast, handy, lightweight, and compact in size. The cutting process occurs in multiple stages. Additionally, we have minimized the need for invasive probes during this procedure, streamlining the process and reducing the overall operation duration.

BACKGROUND

Vitreoretinal surgery encompasses a spectrum of disorders, including Rhegmatogenous Retinal Detachment and Traumatic Vitreo Retinal Surgeries. The crucial element in vitreoretinal surgeries involves the removal of the vitreous gel with the aid of Vitrectomy cutters.

The vitreous is a continuous gel that is attached to the neural retina. During the process of removing the vitreous for ophthalmic surgery, smaller fragments are removed in comparison to larger ones

ALLIGNMENT WITH 2023 G20 THEME

This invention represents a paradigm shift in surgical innovation. With a focus on sustainability by allowing the rotating cutter replacement, it champions eco-conscious practices crucially discussed at the G20. This "Made in India" marvel not only showcases technological prowess but also presents economic advantages, reducing healthcare costs and fostering a circular economy—themes resonating with the G20's commitment to global resilience. As the world unites at the G20 for a healthier future, this invention stands as a testament to collaborative efforts, epitomizing how ingenious solutions can concurrently address global sustainability objectives and promote economic resilience on the G20 stage.

MOTIVATION

Here are some key requirements we have kept in mind driving our design.

- The process should be **minimally invasive.**
- The design must incorporate a suction mechanism, that is **concentric** so that it will **increase** the efficiency and the **cut rate** of the tool. The suction will be constructed using an external pneumatic unit.
- The instrument must have dedicated control systems for adjustments.
- The instrument must be built such that the extracted material can be disposed of separately.
- Cutting will take place in multiple stages.

Limitations of Other Instruments:

- **Restricted Cut Rates:**
    - Traditional vitrectomy cutters

may be constrained by the limitations in cut rates, affecting the overall speed and efficiency of surgeries.

- **Aspiration Line Blockage:**
  - The production of larger vitreous gel chunks by certain cutters may contribute to aspiration line blockage, causing disruptions during surgery.
- **Maintenance Complexity:**
  - Many traditional devices are entwined with sophisticated pneumatic and electrical systems, resulting in heightened maintenance costs and more intricate operational configurations.
- **Extended Surgery Duration:**
  - Owing to lower cut rates and potential disruptions, traditional vitrectomy cutters may lead to prolonged surgery durations, impacting both surgeons and patients.
- **Surgeon Fatigue Risk:**
  - Prolonged surgeries and fatigue interruptions in workflow may amplify surgeon fatigue, potentially compromising overall surgical precision.
- **Higher Operational Expenses:**
  - The intricate nature of traditional devices may result in higher operational expenses, encompassing maintenance, repairs, and replacements of intricate components.
- **More Invasive:**
  - Traditional procedures insert three probes into the cavity (Figure 1), our instrument can do the same in just two probes.

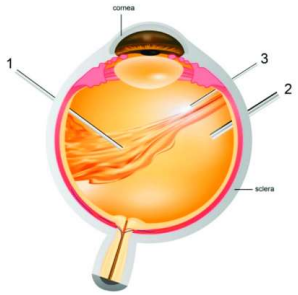


Figure 1: Traditional Vitrectomy

(1: Vitrector, 2: Infusion pipe, 3: Light pipe)

INSIGHTS

- **Improved Cut Rates:**
  - Currently, most of the cutters have a maximum cut rate of around 7000 cuts/minute. Increasing cut rate/minute will lead to suction of a smaller volume of the vitreous gel. This also mean that Vitreoretinal surgeons can go extremely close to the retinal surface enhancing a better, safer and complete vitreous removal. The cut-rate depends upon the motor sped. In this invention the motor speed may reach more than 10000 rpm/cut.
- **Easy Maintenance:**
  - In traditional vitrectomy we need a new cutter for every new surgery to be done. Currently, every day around 40000-50000 new cutters are opened worldwide. The normal cost varies from INR 10000/cutter. In this invention the rotating cutter can be removed and be replaced with a new one instead of replacing the whole cutter.
- **Preventing Aspiration Line Blockage:**
  - In traditional vitrectomy the blocking of the aspiration line creates a major problem. It could also cause disruptions during the surgery. In this invention the life

cycle of the aspiration line improves which avoids clogging. In this invention the aspiration line will move through the sideways of the casing (Figure 2) and will be connected with the sealed chamber.

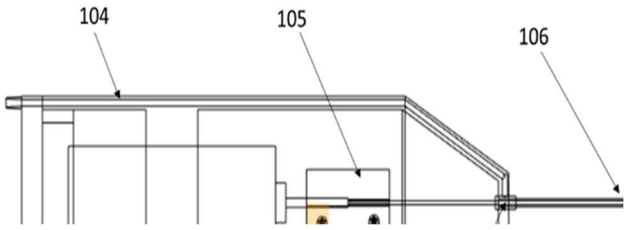


Figure 2: Cutter showing the Aspiration Line

(104: Aspiration Line, 105: Commutator, 106: Cutting tool)

- **Reduced Surgeon Fatigue:**
  - The surgeon is required to look into the eye through the cornea to do the surgery. This tends the surgeon to get fatigued. In this invention the surgeon feels less fatigue due to the increased cut-rate.
- **Reduced Surgery Duration:**
  - Vitrectomy surgery takes a long time to perform. The average vitrectomy surgery takes 30 to 45 minutes to perform. In this invention the cut-rate is increased which results in less operational time.
- **Lower Operational Expenses:**
  - Vitrectomy has been performed by the dedicated instrument which consists of different parts such as handpiece, light, suction system, etc. Apart from this, the instrument is also connected with different electrical and pneumatic lines which increases its operational and maintenance cost. This invention requires only a vitrector and a pneumatic system to maintain the pressure inside the eye.
- **Less Number of Openings:**
  - Normal vitrectomy is done by making three openings in the eye. One is for the Vitrector, one for the light pipe and the other for the infusion pipe. In this invention we have the need of only two openings, one for the vitrector and one for the infusion pipe (Figure 3). The light will already be attached to the vitrector.

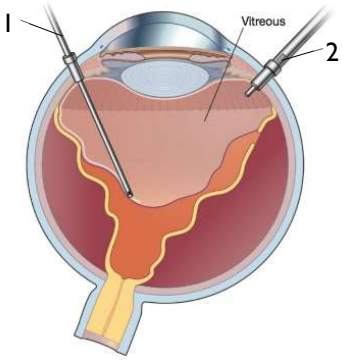


Figure 3: Our Vitrectomy

(1: Vitrector, 2: Infusion pipe)

DEVICE CONSTRUCTION

Basic Components

- **Suction Mechanism:**
  - A Vitrectomy cutter has two coaxial cylinders in which the outer cylinder has a suction window at the tip to absorb the gel due to negative suction pressure.
- **Cutter Mechanism:**
  - The cutting tool is coaxial with the suction Cylinder and the tissue are cut by the

coaxial rotating motion of the inner cylinder.

- **Aspiration Line:**
  - The hand piece is connected to Aspiration line through the Aspirational Port. This will start to suck the gel like material or tissue through suction vent in a hollow shaft.

Cutting Operations

- The device is connected to an electric motor which starts to rotate the cutting tool (106) according to the required rpm value.

- The cutting tool (106) is concentric with the hollow shaft (107). The connector between the casing (100) and the shaft has a sealed chamber (108) which connects aspiration line (104), hollow shaft with suction vent (107) and cutting tool (106).

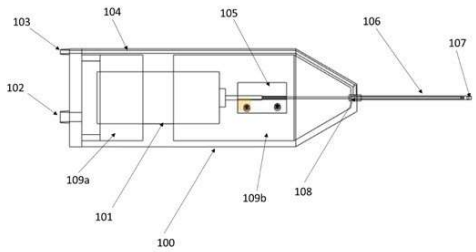


Figure 4: Device Overview

- This sealed chamber (108) has sealing which maintains the suction and bearing to allow the rotating motion of the tool. The port (202) sucks the tissue inside the tube and takes it to cutting tip (201).

Figure 5: Enlarged view of the Cutting tool portion with sealed chamber.

- The port (202) sucks the tissue inside the tube and takes it to cutting tip (201). The cutting tool (301) chips the tissues and then the tissues are extracted from device through aspiration line.

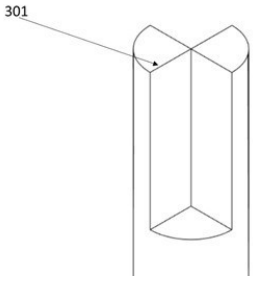


Figure 6: Cutting tip design for proposed cutter

Multistage Rotatory Cutting:

- During Surgery, the operator will have control over switching action and movement of handpiece. Turning the switch on will enable the disposable motor to rotate up to 1000rpm/cut. The disposable motor will rotate enabling multistage cutting and the aspiration system will start simultaneously to suck material inside the hollow shaft.

- The gel and tissues will undergo first stage cutting and then move for next stage size reduction to avoid agglomeration of material in aspirational line. The aspiration path will move sideways of handpiece and reach up to sealed chamber and then follow the path of cutting tool.

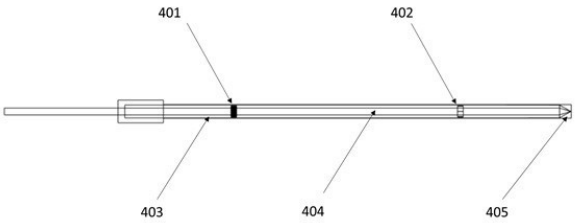


Figure 7: Cutting tool resting on the tip of hollow shaft

- To avoid Rotational Vibrations tools may rest on the tip of the hollow shaft (405). The tools may have several cutting tips (402) or meshes (401) at different positions on a solid cutting shaft (403) to enable multistage mesh cutting.

- According to the invention, this device has

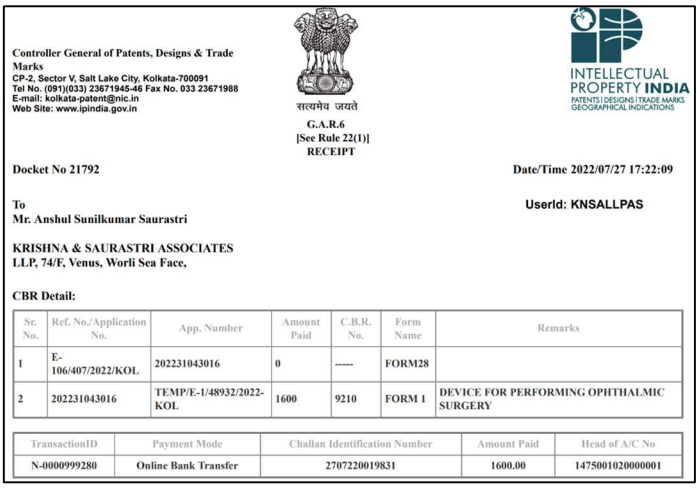
multiple stage cutting which further reduces the size of tissue and improves the life cycle of the aspiration line by avoiding clogging. The overall operational time is reduced by an increase in the number of cuts per cycle with edges rotating.

Figure 8: Mesh for size reduction of extracted gel after cutting

CONCLUSION

- **Invention of multistage cutting ophthalmic device used for the extraction of the gel like structure comprising;**
    - A portable handpiece having a motor, sealed chamber, aspiration line, cutting tool and external tube.
    - The handpiece design will be portable, here instead of changing the handpiece every time one can change only damaged parts.
    - The hollow shaft works as a covering for cutting tool and passage for aspiration line which follows a separate path within the handpiece body.
    - The tool and the shaft create a small chamber for suction of the gel like material.
- **The multistage cutting ophthalmic device comprises a tool with cutting edges on its periphery at a certain distance axially from the tip and may have a magnetic coupler to connect cutter with motor shaft.**
- **The device will have a sealed chamber sealed by mechanical sealing or a selastic membrane.**
- **The device will have a filter and a one-way mechanical valve to divert and restrict flow of vitreous gel in the required direction.**

PROOF



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2	202231043016	TEMP/E-1/48932/2022-KOL	1600	9210	FORM 1	DEVICE FOR PERFORMING OPHTHALMIC SURGERY

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