

# Safe Puncture Optimized Tool

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## An short introduction to Retinal Vein Cannulation

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# Retinal Vein Occlusion

- Retinal vascular disorder
- Blood circulation blocked by a clot
- Outcome: vision blur, then vision loss
- Affected population:
  - 4.4 out of 1000 people
  - Aged population
  - 1.3 Mio people in the US, 1.3 Mio in Europe



[https://en.wikipedia.org/wiki/Retina#/media/File:Fundus\\_photograph\\_of\\_normal\\_right\\_eye.jpg](https://en.wikipedia.org/wiki/Retina#/media/File:Fundus_photograph_of_normal_right_eye.jpg)

# Retinal Vein Occlusion

**Healthy Retina**



**Retinal occluded vein**



# Problem Statement

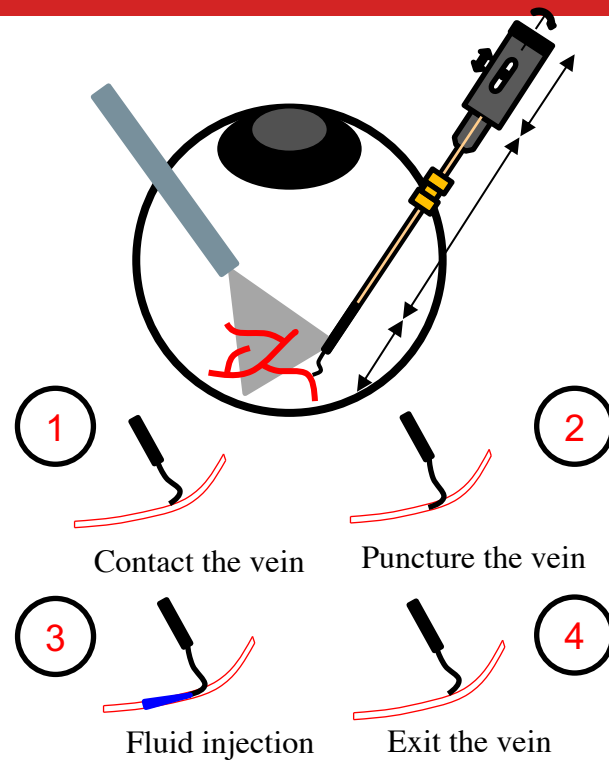
## Retinal Vein Cannulation (RVC)

RVC is an effective but delicate treatment of RVO.

The retinal vein is punctured to inject fluid.

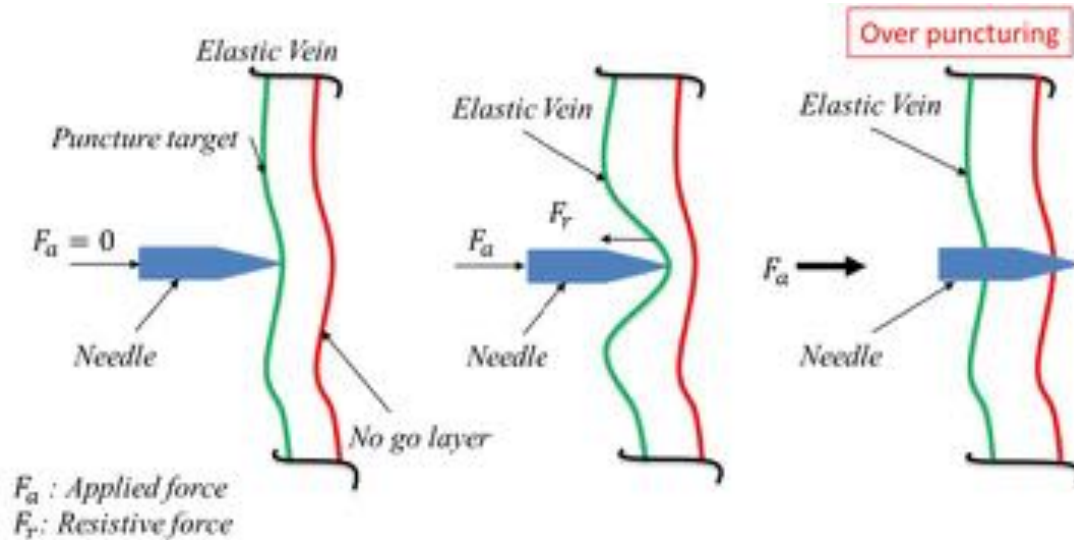
### Challenges of RVC

- The vein diameter is less than  $100\ \mu\text{m}$ .
- The tool has to fit in a cylinder of  $900\ \mu\text{m}$  diameter.
- The puncture force is below the surgeon sensing capability.
- The tool is held in position for several minutes.
- Surgeon tremor is about  $100\ \mu\text{m}$ .



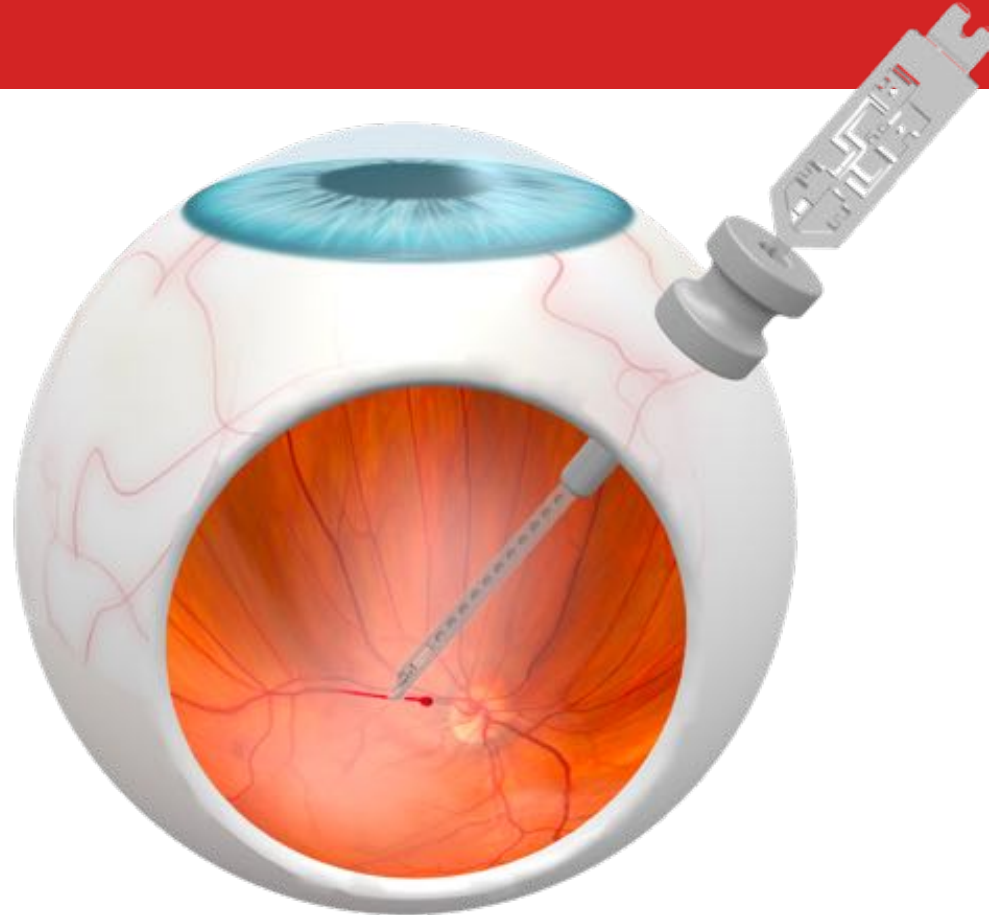
# Retinal vein cannulation

- Main risk: over puncture

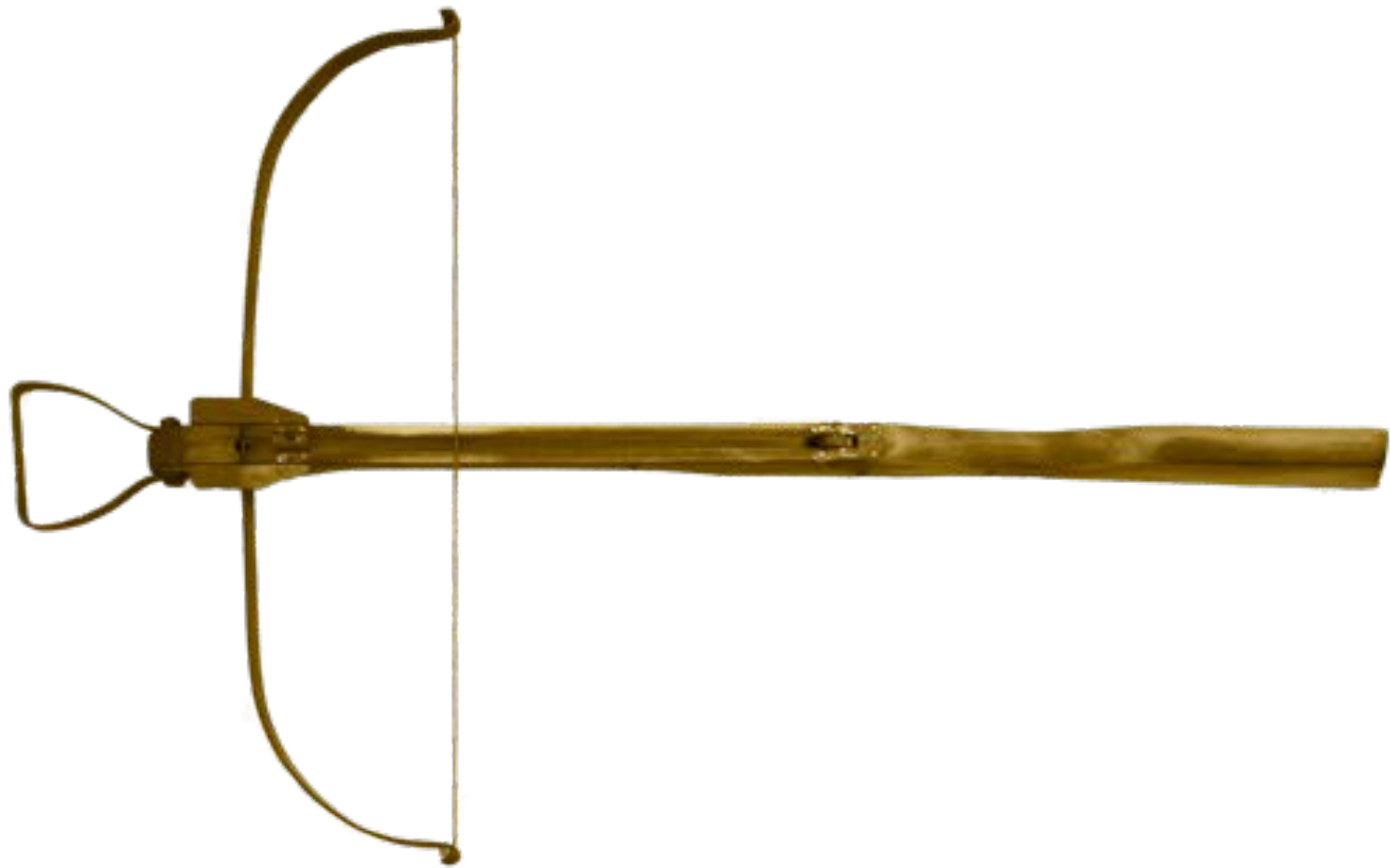


# Developed tool

- Puncture with a **defined stroke and force** (bistable mechanism)
- Flexure-based **monolithic** construction
- **Microfluidic channel** for injection
- **Force sensing** at the tip
- Femtosecond laser manufacturing
- Handheld tool



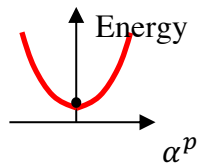




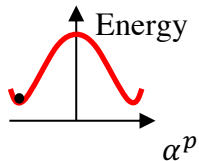


# Mechanical Realization

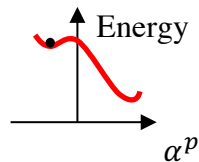
Initial State



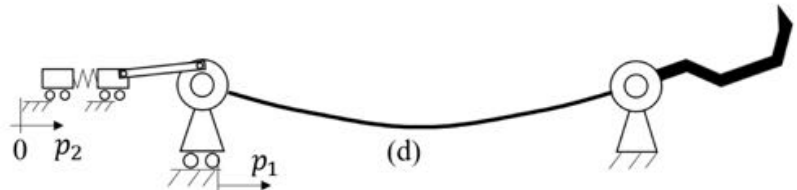
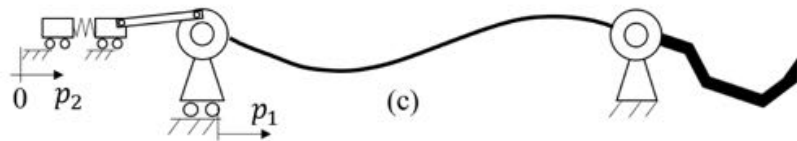
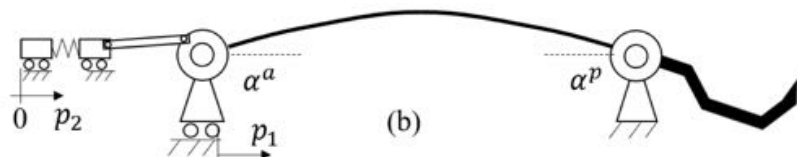
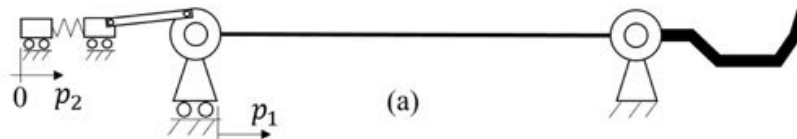
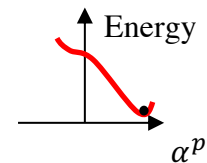
First stable state



Switching



Second stable state

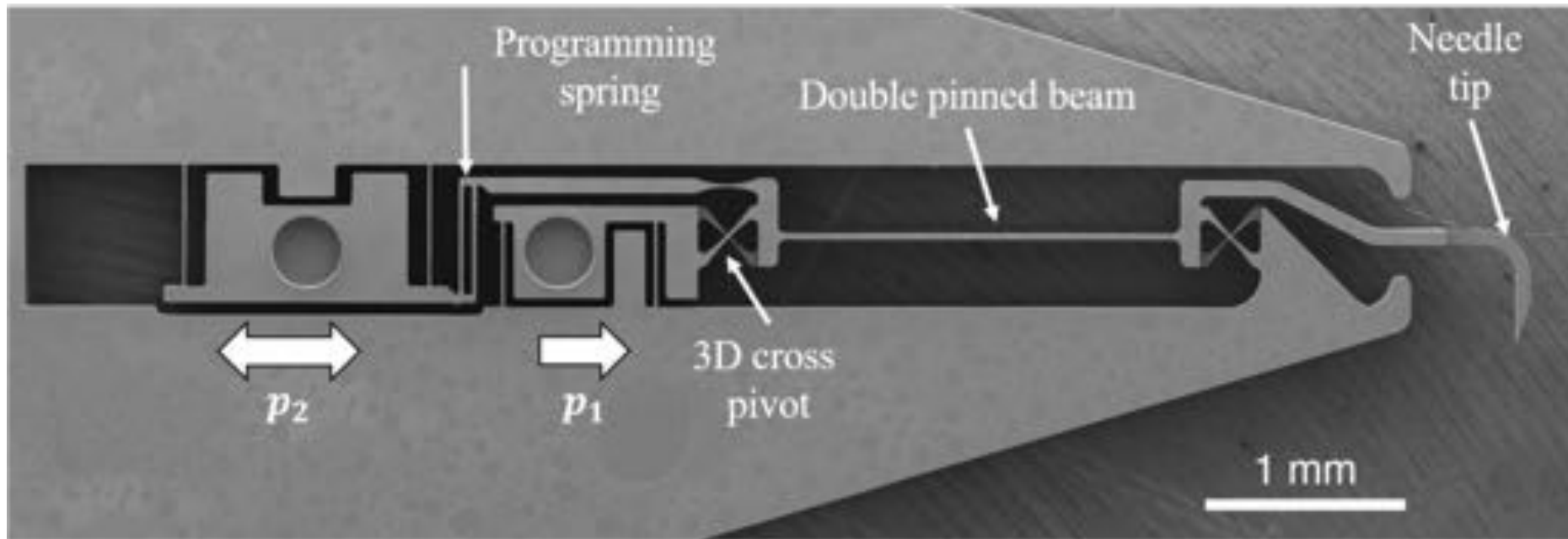


# Bistability

- **Repeatable and defined** puncture force and stroke
- Independence of actuation input
- **Tuneable** puncture force and stroke

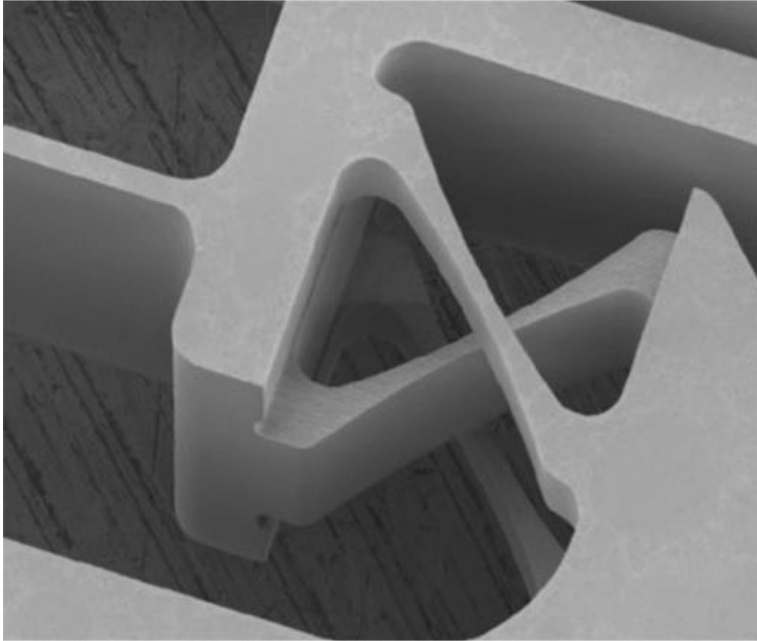


# Developed tool (1st generation)

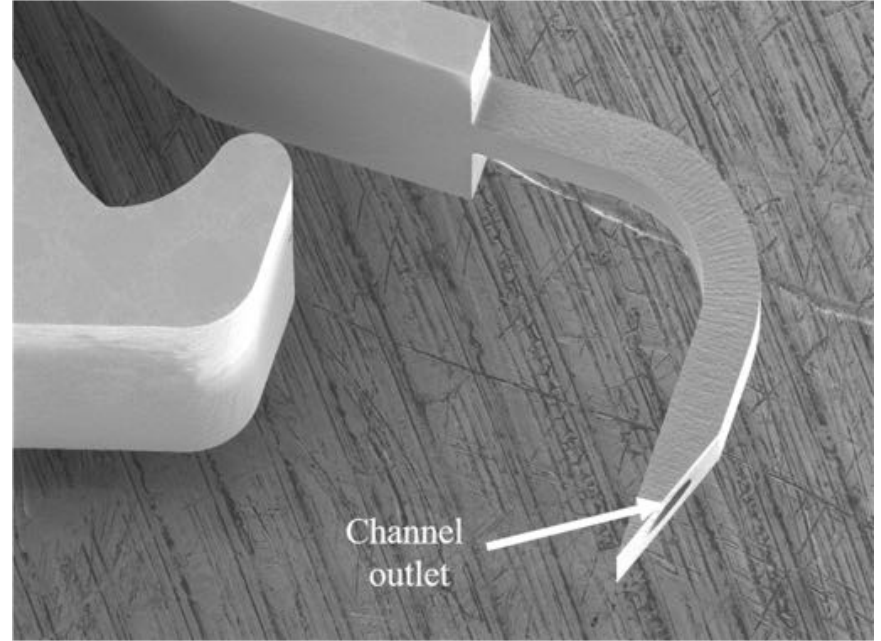


# Developed tool (1<sup>rst</sup> generation)

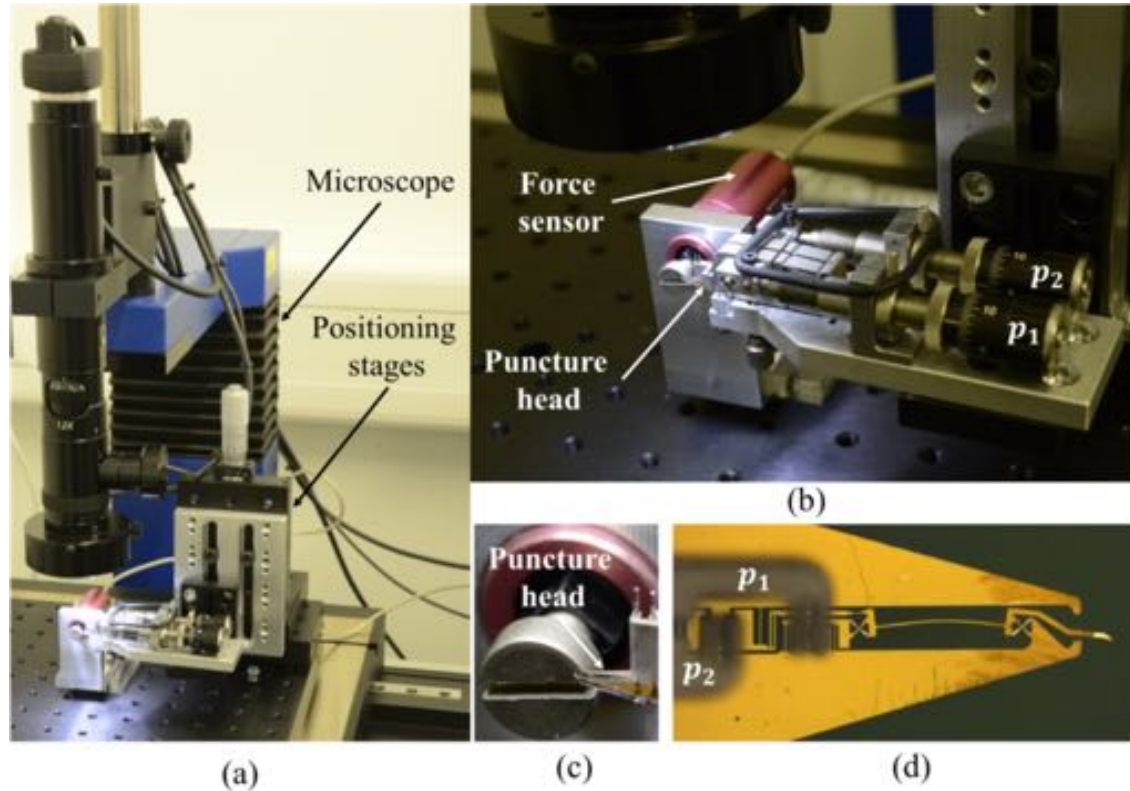
3D Cross Pivot



Fluidic Channel



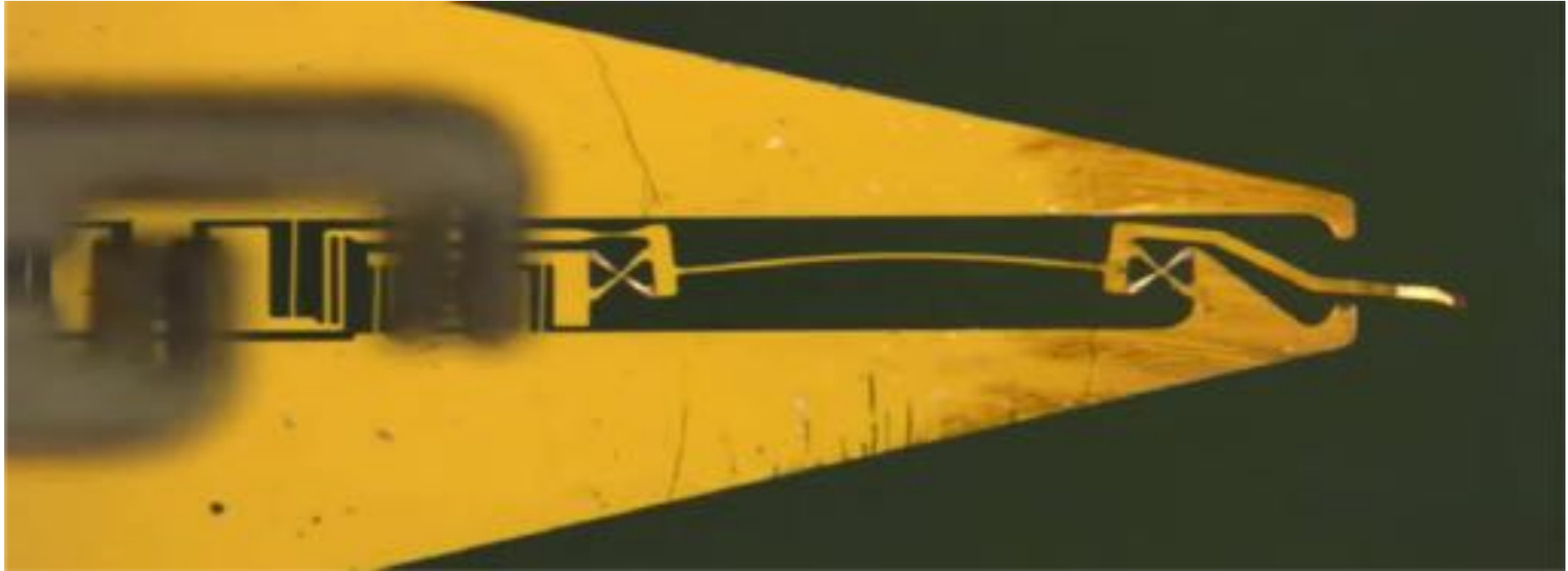
# Experimental setup



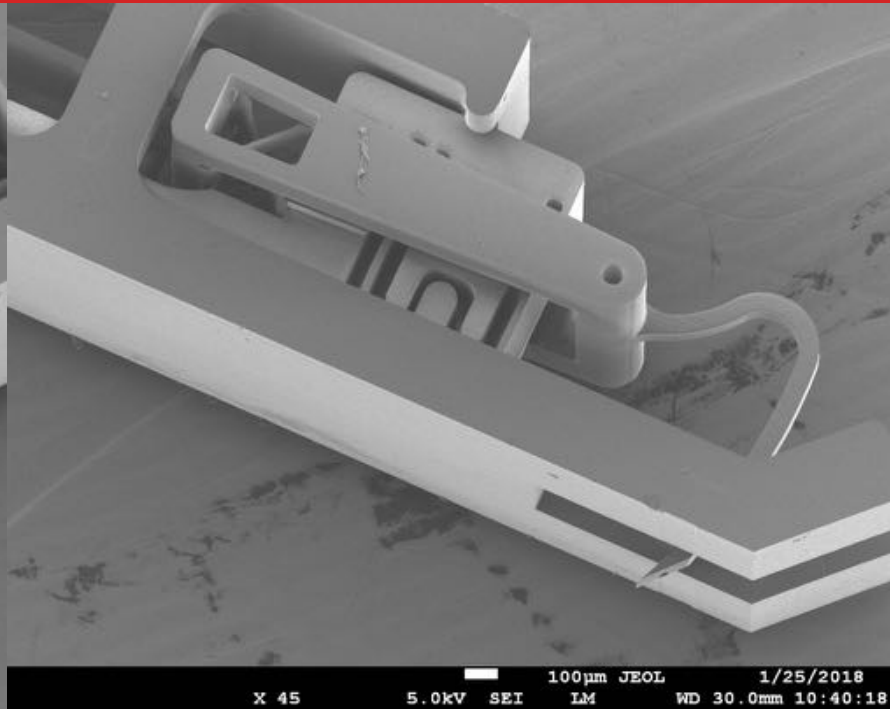
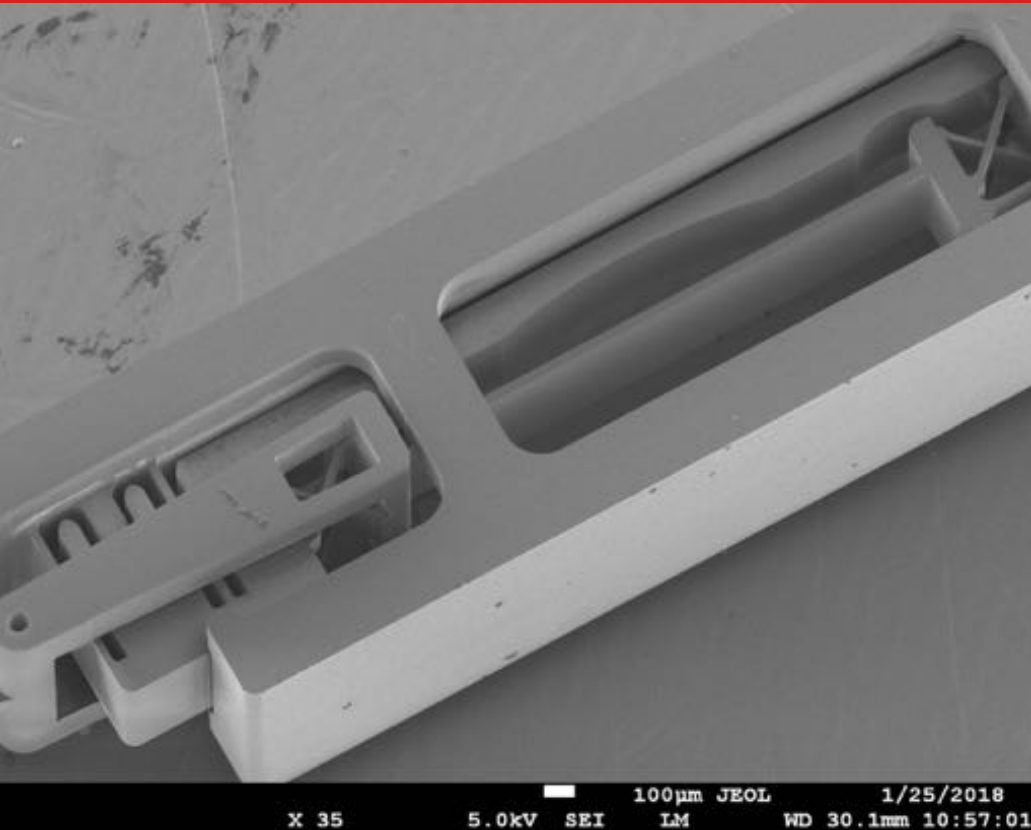
# Stable States of the Puncture Tool



# Programming and Actuation

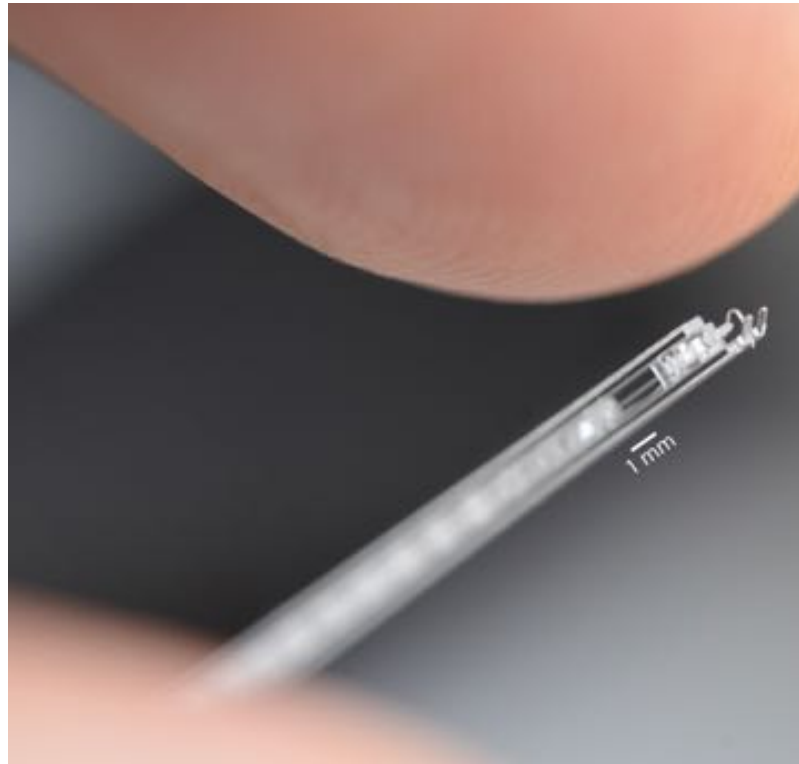


# Developed tool (2<sup>nd</sup> generation)





# Developed tool



# Achievements to date

- **Monolithic** glass prototype with working mechanism for puncturing
- Ergonomic **handle** + interface
- **Successful and repeatable cannulation** on pig eyes and chicken embryo
- Two **patents** pending
- **Force sensing** principle
- Fluidic channels