KU LEUVEN

Surgical Robotics
New trends in research

Dept. Mechanical Engineering,
assoc. prof. dr. ir. E. Vander Poorten

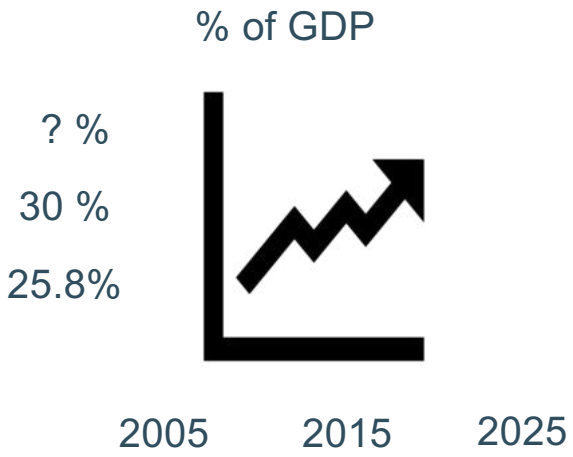
https://www.mech.kuleuven.be/en/pma/research/ras

Outline

- Surgical Robotics - Background
- New trends

Background

1. temperature
2. gas bill
3. age
4. taxes
5. healthcare costs



Double the number of interventions are now approved for treatment in day-hospital, reducing number of nights in hospital

Minister Frank Vandenbroucke (Vooruit) kondigde donderdag in UZ Leuven aan dat de standaardingrepen die mogen gebeuren via dagopname worden uitgebreid. — © hsb

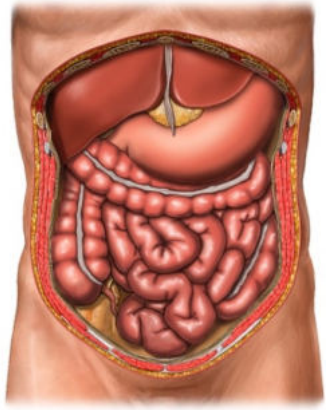
LEUVEN - **Het plaatsen van een knieprothese, het opereren van een galblaas, verschillende oogoperaties: chirurgen mogen ze vanaf vandaag allemaal uitvoeren in het dagziekenhuis. In totaal gaat het aantal ingrepen dat in het dagziekenhuis mag gebeuren van 246 naar 551. En dat is goed nieuws voor de werkdruk binnen UZ Leuven.**

31.12.2022

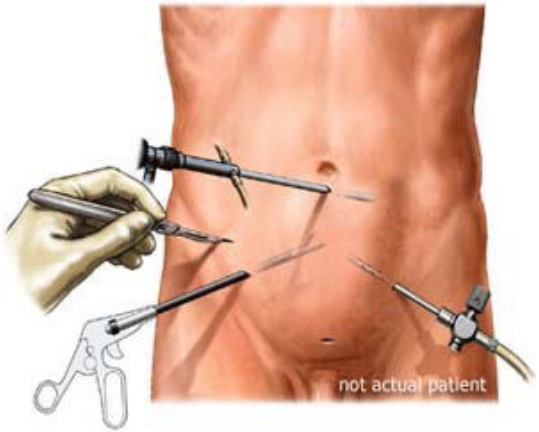
Double the number of interventions are now approved for treatment in day-hospital, reducing number of nights in hospital

Minister Frank Vandenbroucke (Vooruit) kondigde donderdag in UZ Leuven aan dat de standaardingrepen die mogen gebeuren via dagopname worden uitgebreid. — © hsb

LEUVEN - **Het plaatsen van een knieprothese, het opereren van een galblaas, verschillende oogoperaties: chirurgen mogen ze vanaf vandaag allemaal uitvoeren in het dagziekenhuis. In totaal gaat het aantal ingrepen dat in het dagziekenhuis mag gebeuren van 246 naar 551. En dat is goed nieuws voor de werkdruk binnen UZ Leuven.**



classic
overnight

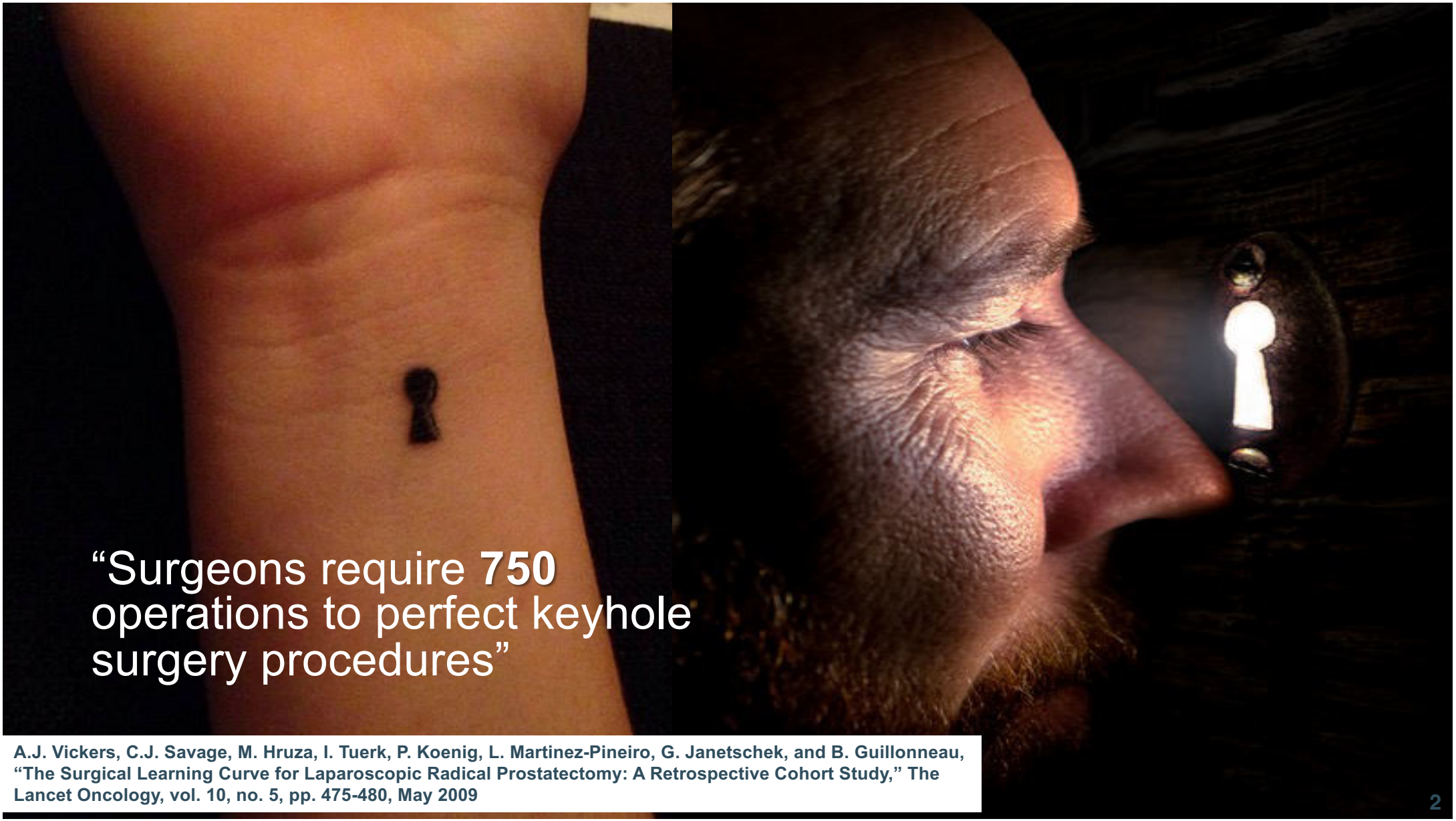


MIS
day-hospital

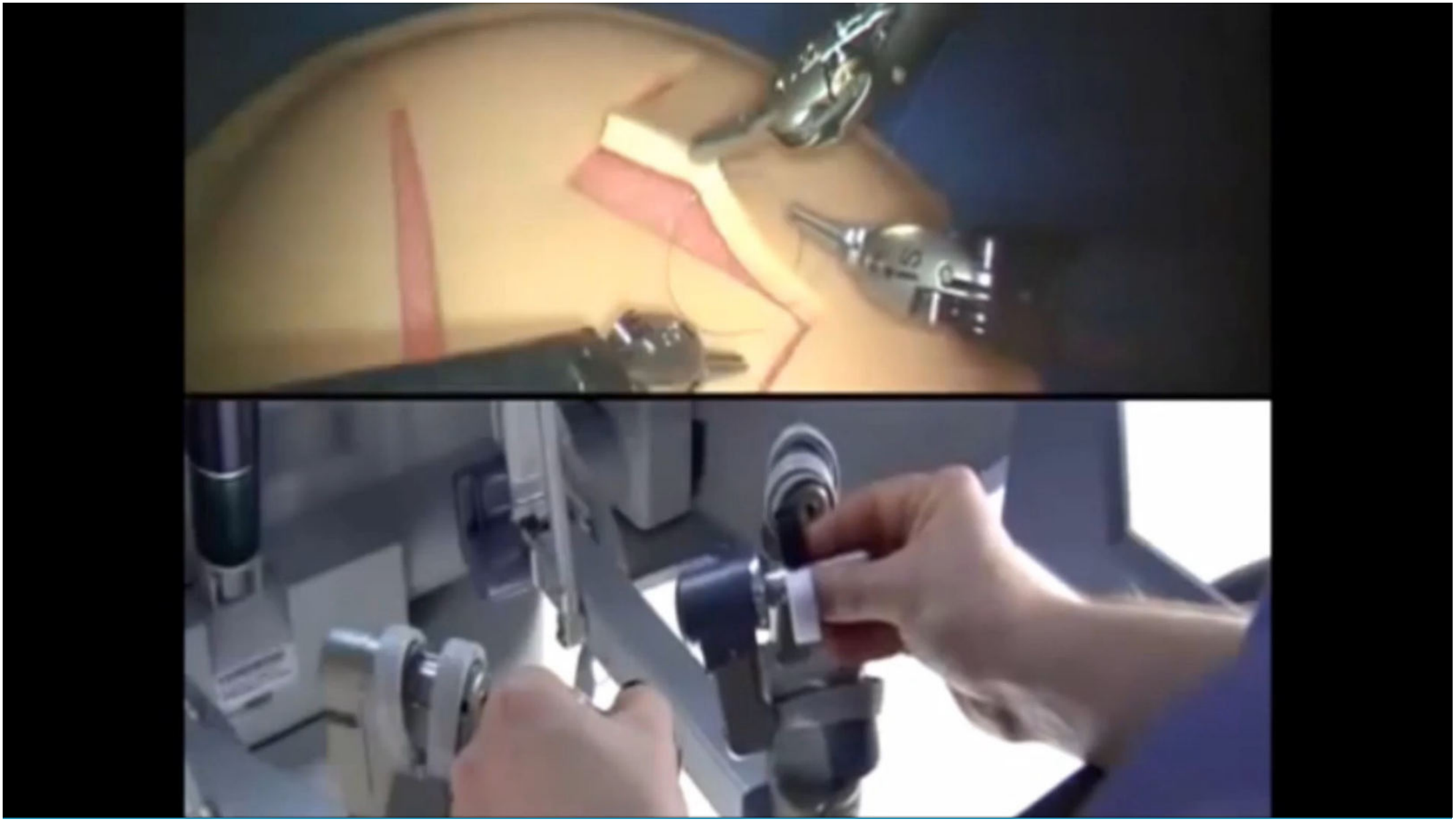
	700.000 (6%)		246	644.000 (5.7%)
target	479.000 (4.1%)		551	865.000 (7.4%)
	#/yr (%/pop)			#/yr (%/pop)

population Belgium : 11.7 million

KU LEUVEN



A.J. Vickers, C.J. Savage, M. Hruza, I. Tuerk, P. Koenig, L. Martinez-Pineiro, G. Janetschek, and B. Guillonneau, “The Surgical Learning Curve for Laparoscopic Radical Prostatectomy: A Retrospective Cohort Study,” The Lancet Oncology, vol. 10, no. 5, pp. 475-480, May 2009

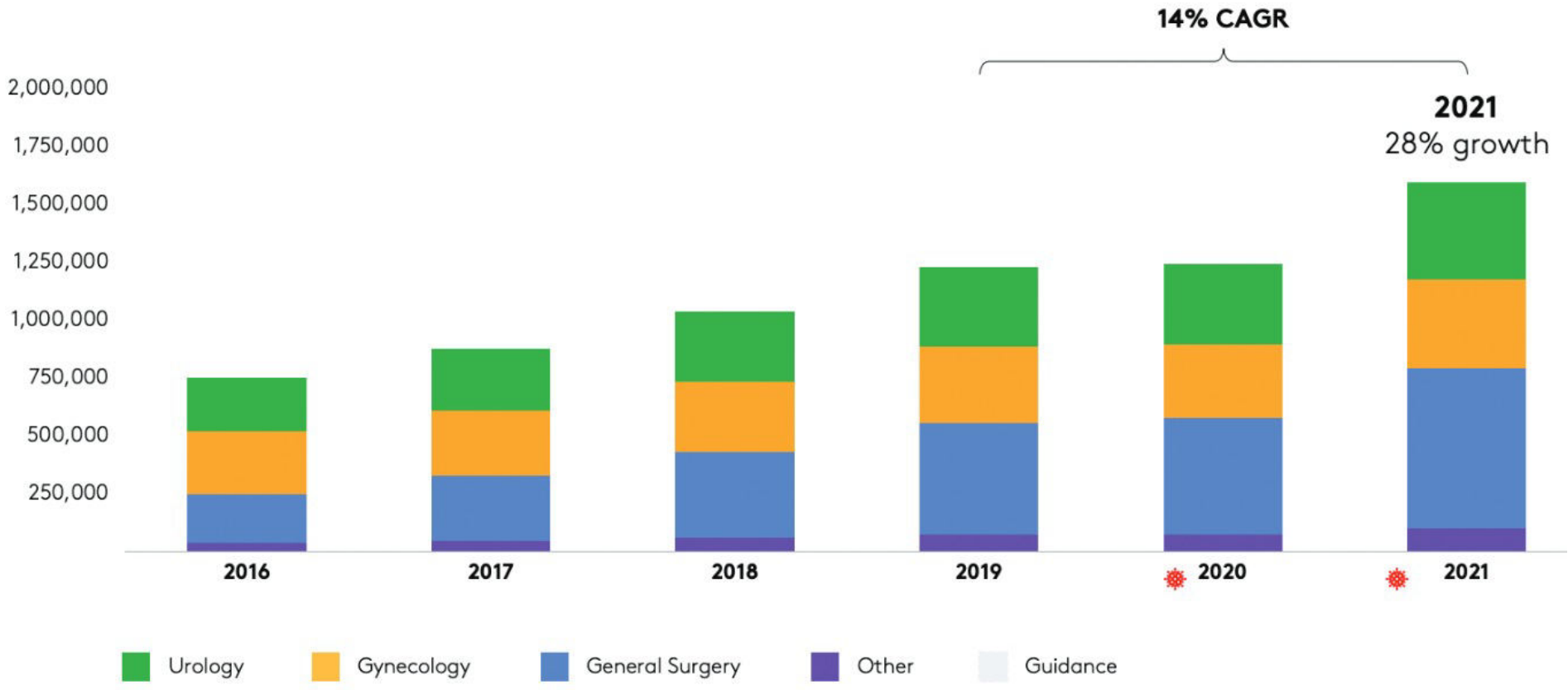


Learning Curve

	open	laparoscopic	robotic	ref
radical prostatectomy	250-1000	200-750	40	[1]
radical cystectomy			16-30	[1]
colorectal cancer surgery		5-310	15-30	[2]
Roux-en-Y gastric bypass		> 100	10-15	[3]

[1] Abboudi, H., et al. (2014). Learning curves for urological procedures: a systematic review. BJU international, 114(4), 617-629.
[2] Barrie, J., Jayne, et al. (2014). Attaining surgical competency and its implications in surgical clinical trial design: a systematic review of the learning curve in laparoscopic and robot-assisted laparoscopic colorectal cancer surgery. Annals of surgical oncology, 21(3), 829-840.
[3] Fourman, M. M., & Saber, A. A. (2012). Robotic bariatric surgery: a systematic review. Surgery for Obesity and Related Diseases, 8(4), 483-488.

Practical Update



Source: Intuitive Surgical, 2021 earnings

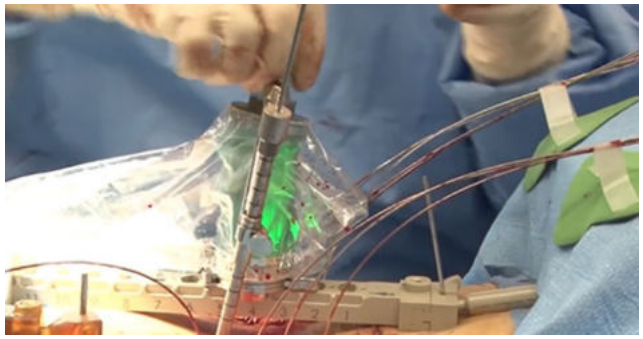
Ranking hardware companies

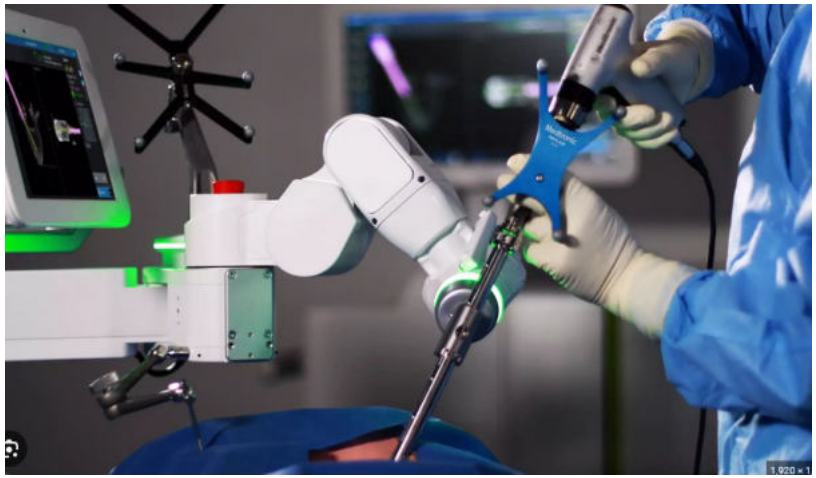
Johnson & Johnson – 386 Bill. US$
Medtronic – 106 Bill. US$
Stryker – 110 Bill. US$

Intuitive – 104 Bill US$
Mercedes – 77 Bill US$
BMW – 70 Bill US$
VW/Audi – 64 Bill US$

FANUC – 27 Bill US$
Olympus – 17 Bill US$
Auris Health – 3.4 Bill US$ → J&J
iRobot – 1.0 Bill US$ (3 Bill 2021/2019)
KUKA – 2.6 Bill US$ → MIDEA (2016)

MAKO – 1.6 Bill US$ → Stryker
MAZOR – 1.6 Bill US$ → Medtronic
Corindus – 1 Bill US$ → Siemens Healthineers (2022-23)
Boston Dynamics – 1.1 Bill US$ → Hyndai (2021)
Accuray – 254 Mill US$ (1.3 Bill. 2008)
Stereotaxis – 136 Mill US$ (11 Bill. 2007)
Blue Belt – 275 Mill US$ → Smith & Nephew
Hansen Medical – 75 Mill US$ → Auris
Robocath – funding 58 Mill raised (2022)
Hocoma (private)
Rewalk – 20 Mill US$





Medical devices
Automative
Industrial Robotics
Service Robotics
Surgical Robotics

Source: Tim Lüth, TUM, Sept. 2023

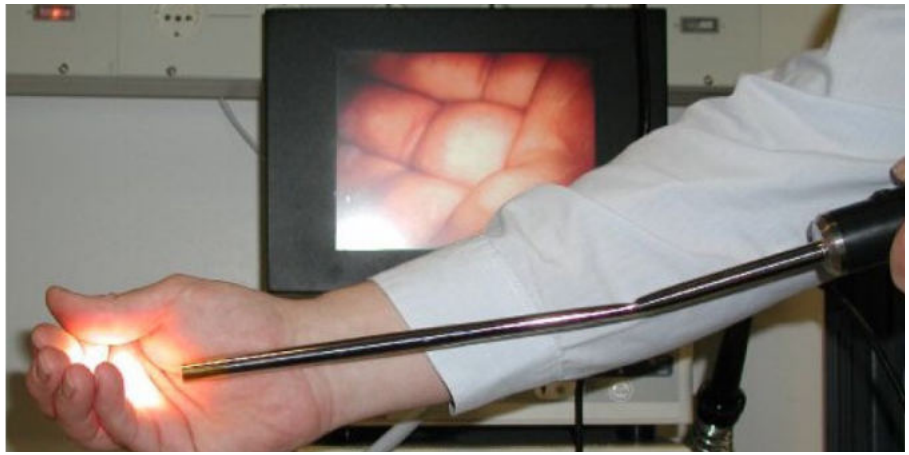
KU LEUVEN

KU LEUVEN

Haptic Feedback

Recent Evolutions

Challenges



increased levels of **trocar site hernia** when operating laparoscopically or robotically [1-3]

[1] F. Helgstrand et al., “Trocar site hernia after laparoscopic surgery: a qualitative systematic review,” Hernia (15), 2, pp.113–121, Apr. 2011.
[2] H. A. Swank et al. , “Systematic review of trocar-site hernia,” Br. J. Surg., vol. 99, no. 3, pp. 315–323, Mar. 2012.
[3] G. Scozzari et al., “High incidence of TSH after laparoscopic or robotic Roux-en-Y gastric bypass,” Surg. Endosc, 28(10)p.2890–2898, 2014.

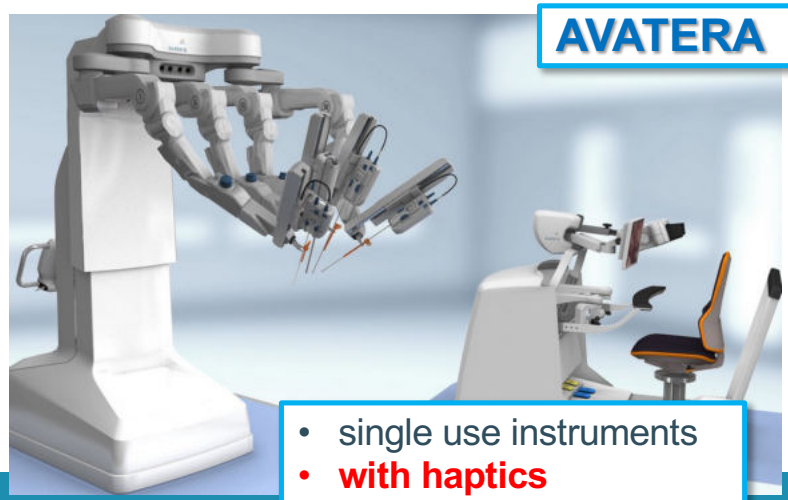
Intuitive Surgical's competition

Senhance

- 3D HD display, eye tracking
- 5mm diameter tools
- **with haptics**

REVO-I

- 20 times re-usable
- **with haptics**



AVATERA

- single use instruments
- **with haptics**

Recent Review Papers :

[1] Rao, P. P. (2018). Robotic surgery: new robots and finally some real competition!. World journal of urology, 36(4), 537-541.
[2] Rassweiler, J. J. and A.S. Goezen, J. Klein, E. Liatsikos, (2017) New Robotic Platforms, Robotic Urology, pp.3-38.
[3] Peters, B.S. et al. (2018), review of emerging surgical robotic technology, Surgical Endoscopy 32: 1636-1655.

da Vinci 5 – with haptic feedback

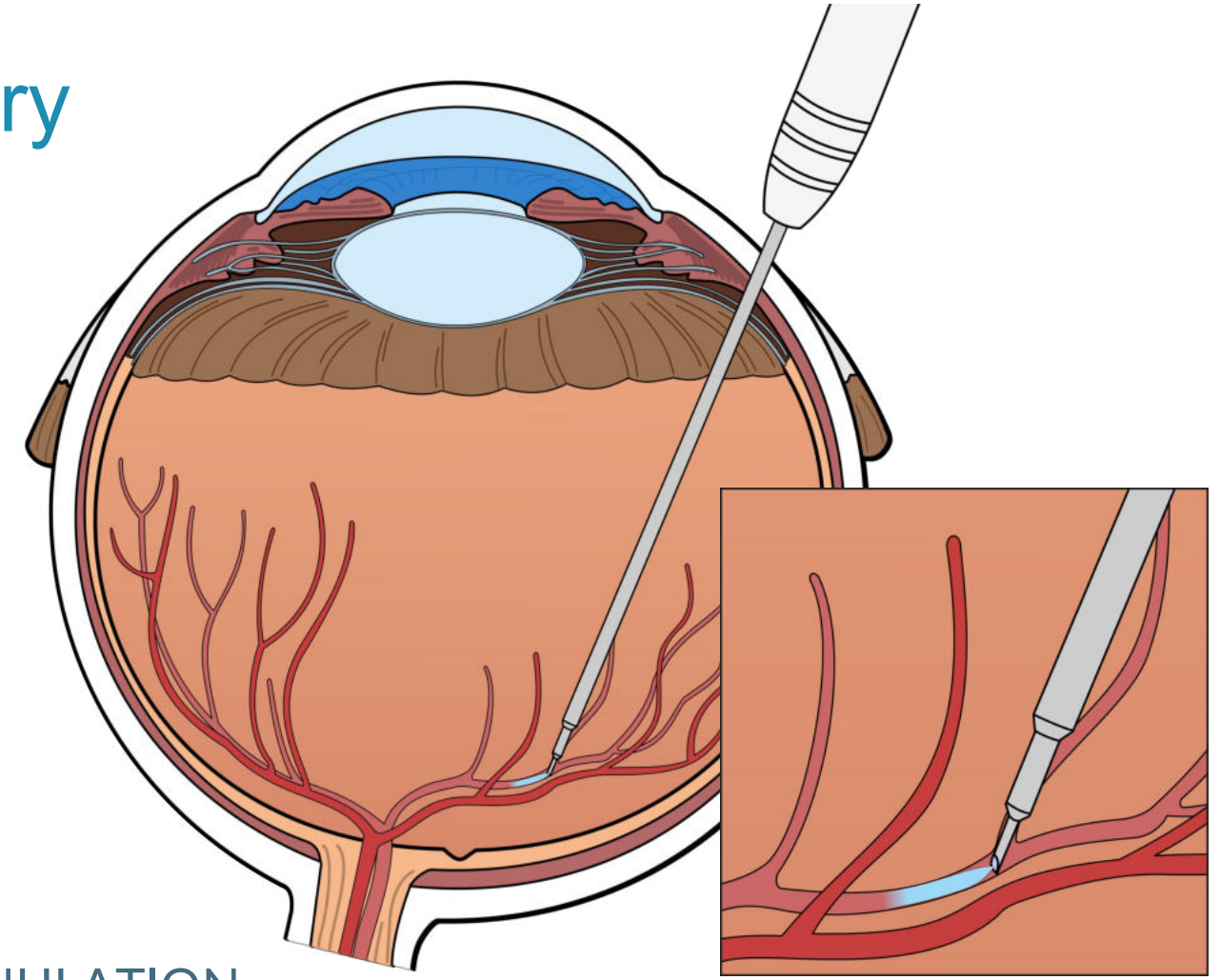
14 years of development ….

KU LEUVEN

Increased Precision

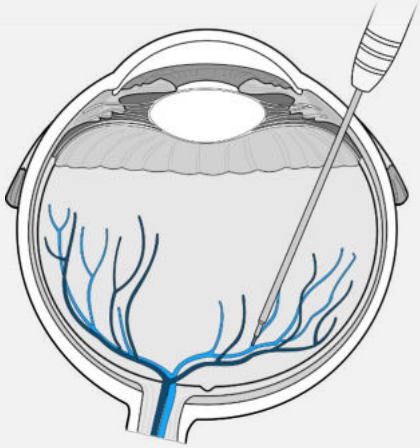
Recent Evolutions

Micro-surgery

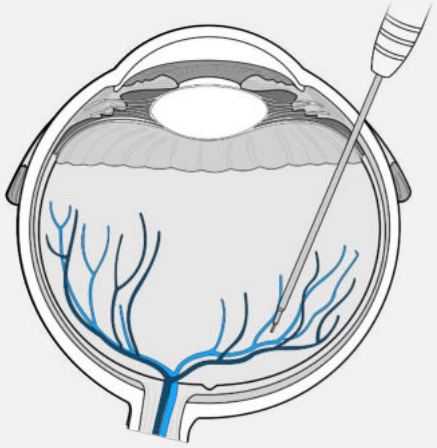


RETINAL VEIN CANNULATION

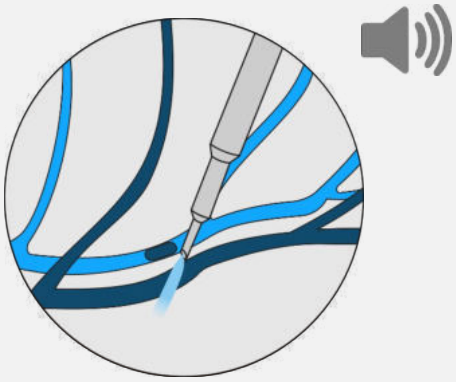
Challenges



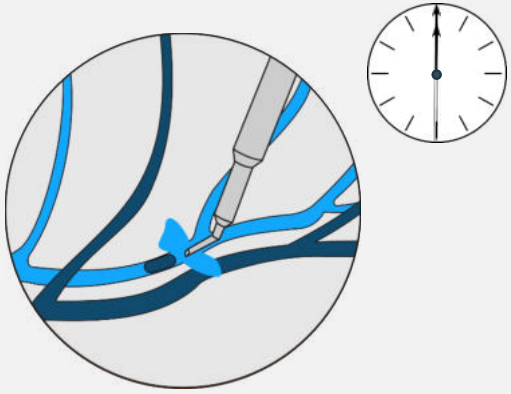
EYE STABILISATION



HAND STABILISATION

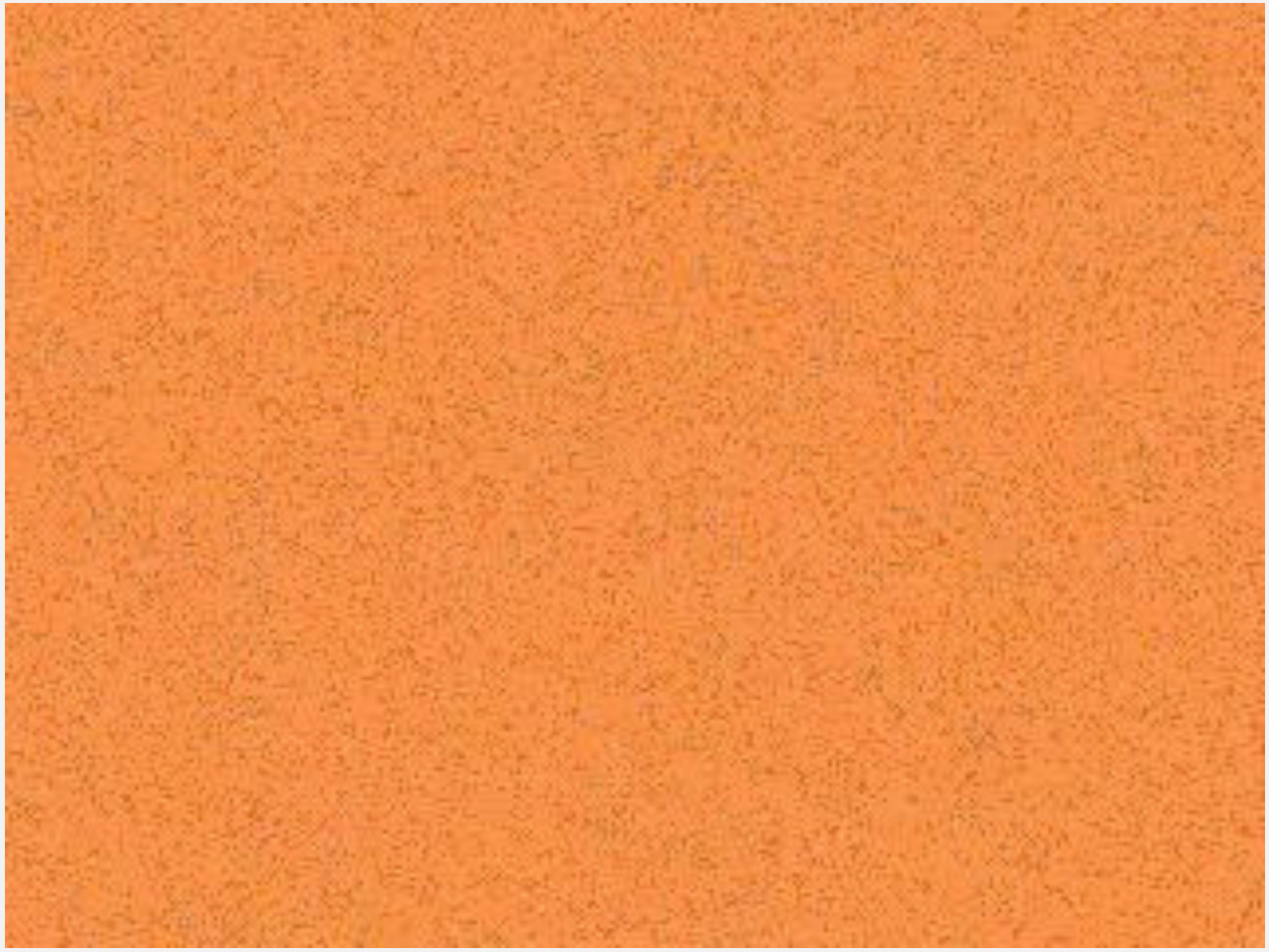


PUNCTURE ASSISTING



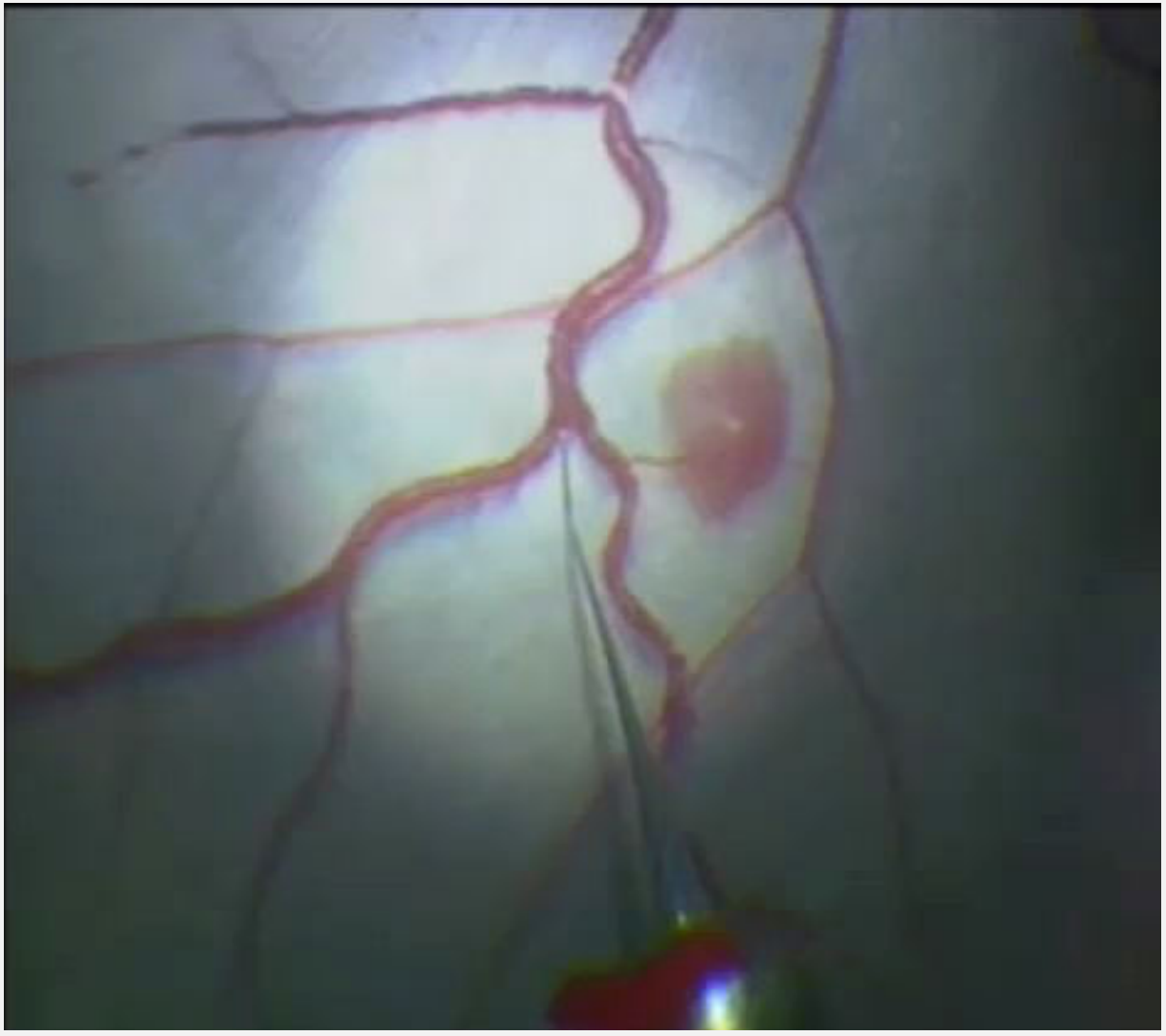
TOOL STABILISATION

Manual




MYNUTIA
CONFIDENTIAL 18

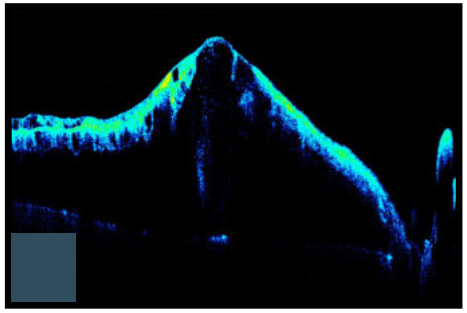
Robotic Approach

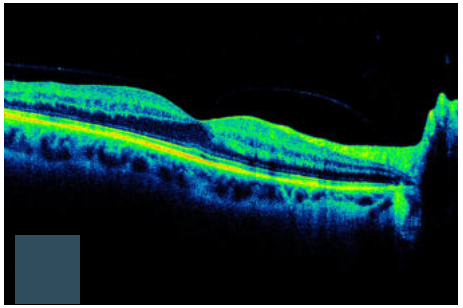


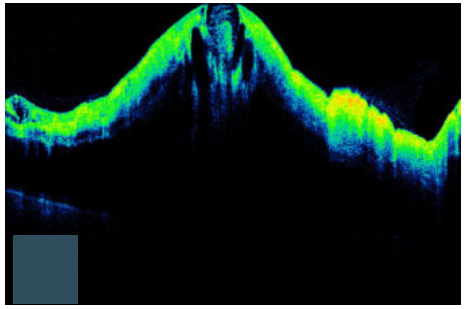
Phase 1 Clinical Trial

UZ Leuven, Prof. Stalmans

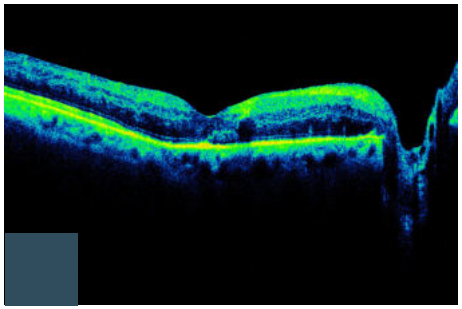
before surgery

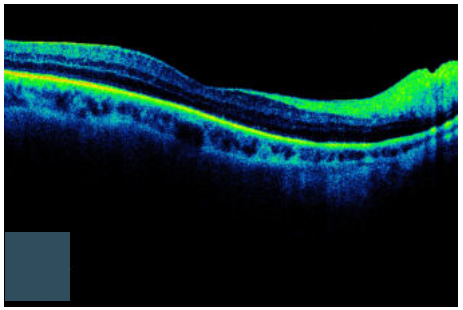


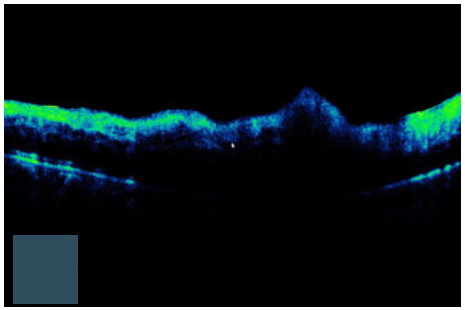




patient 1 patient 2 patient 3







10 days after surgery

KU LEUVEN

Increased Ergonomy/Efficiency

Recent Evolutions

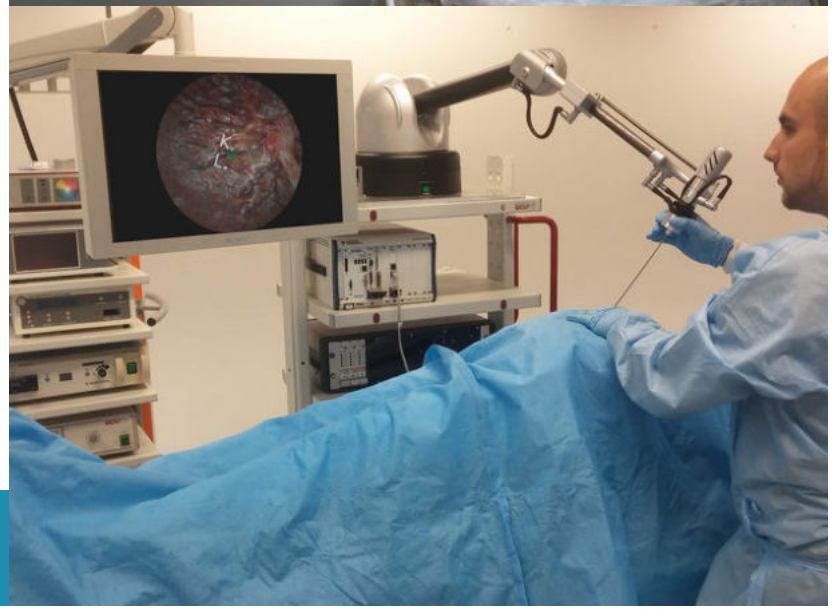
Laparoscopic assistants

UZ Leuven, Prof. J. Deprest

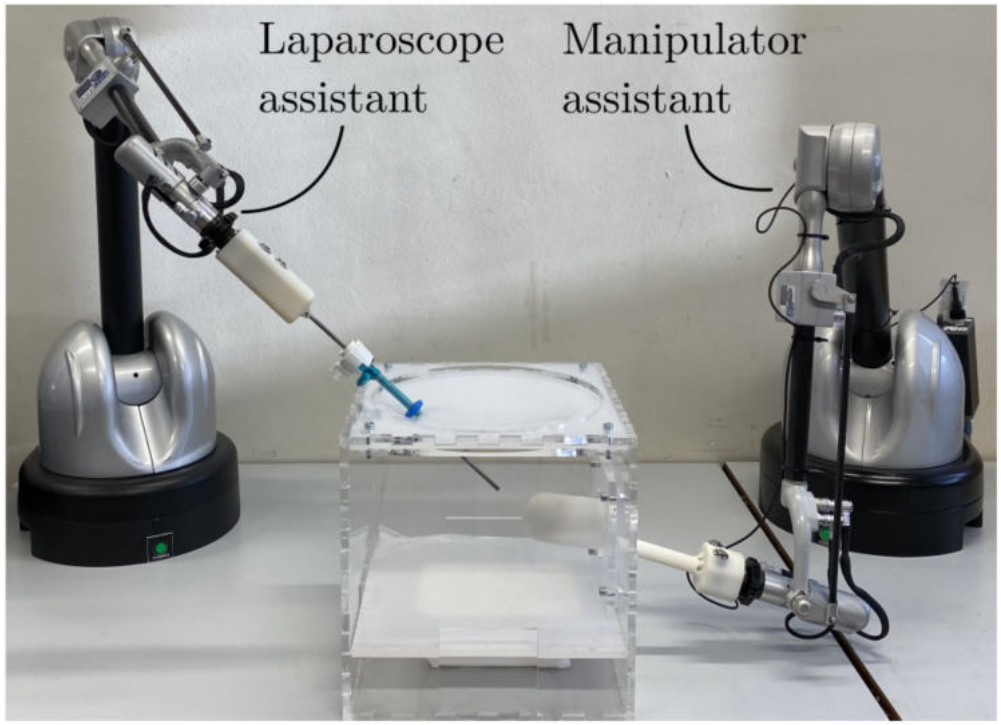
- sacrocolpopexy
- ergonomy/efficiency challenges

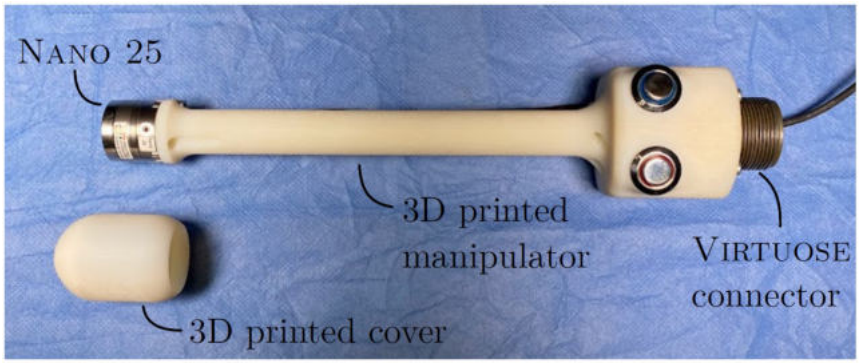
Robotic Comanipulation

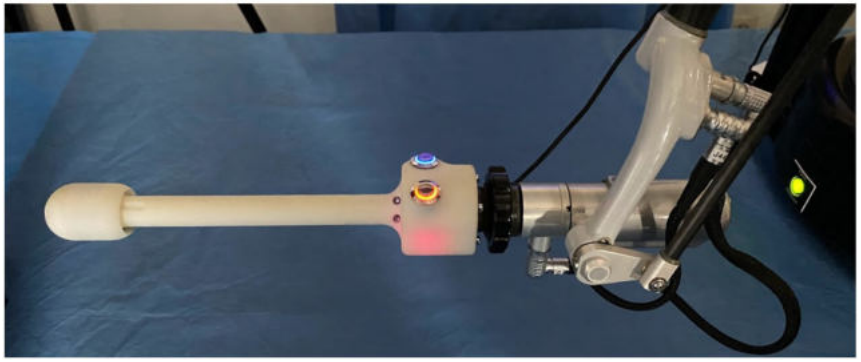
- hands-on operation
- clinician at bed-side



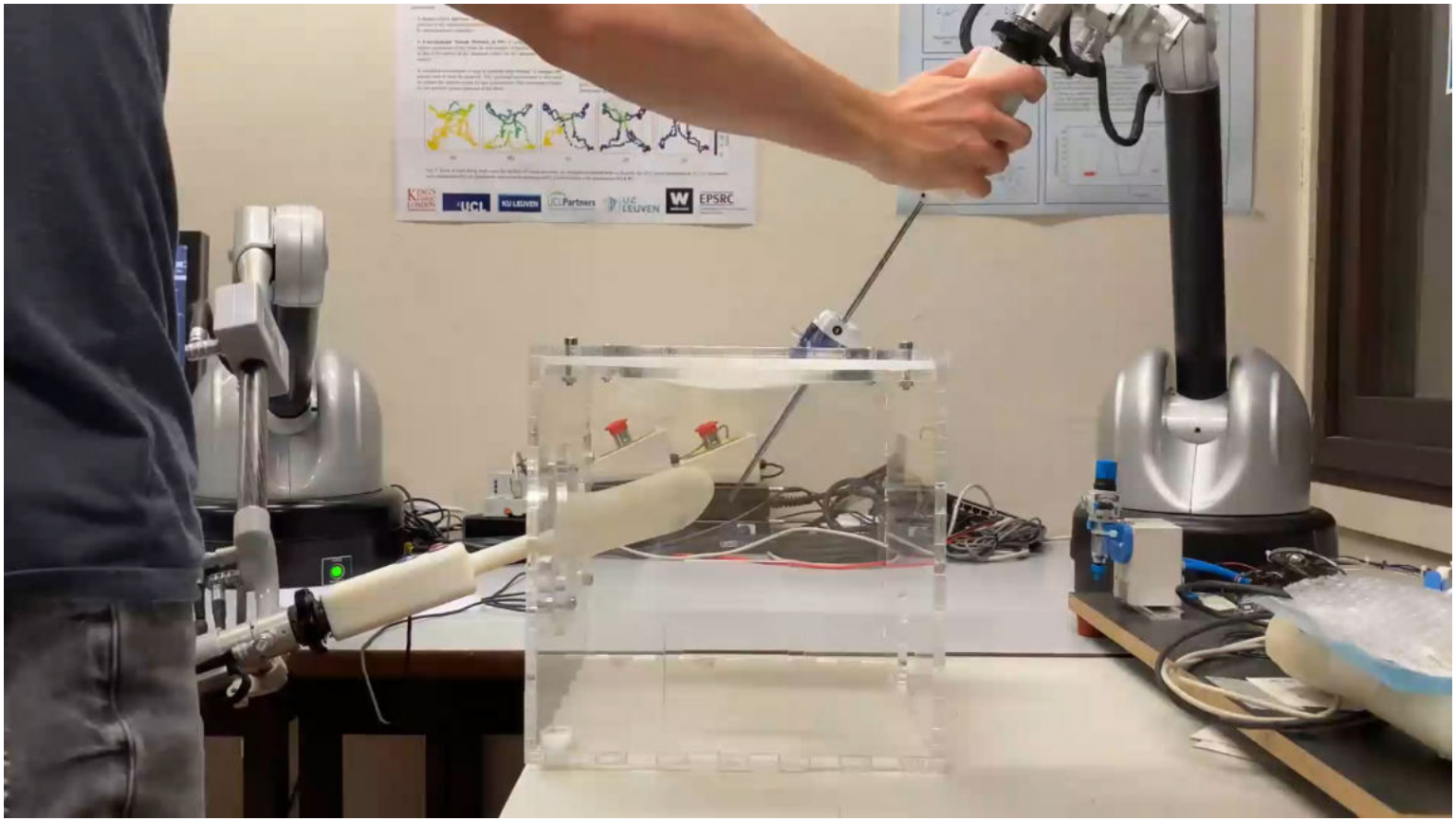
Comanipulation



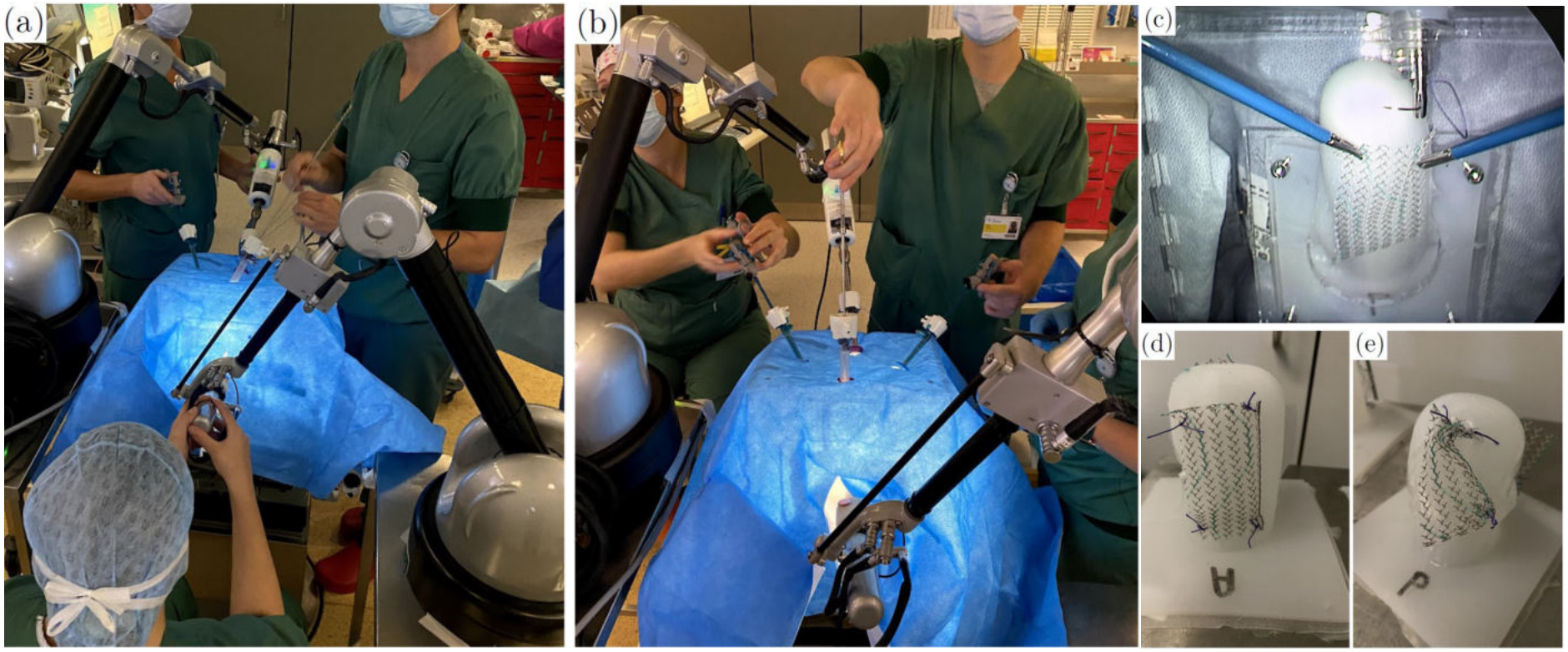




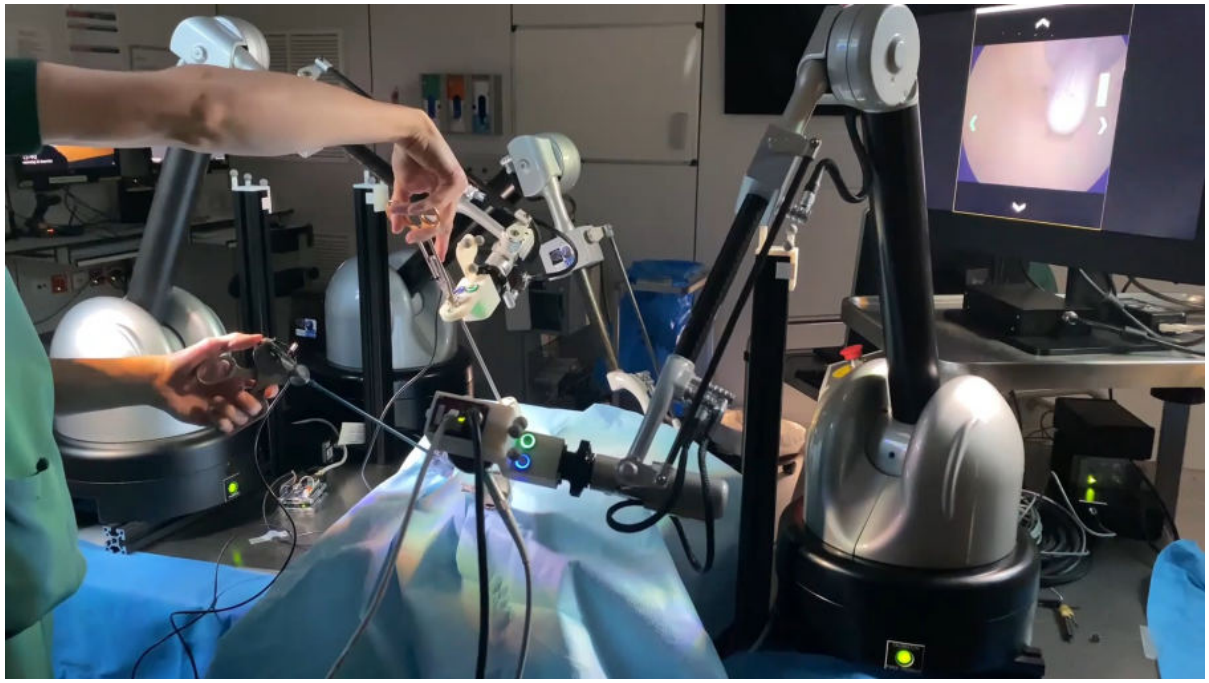
Comanipulation

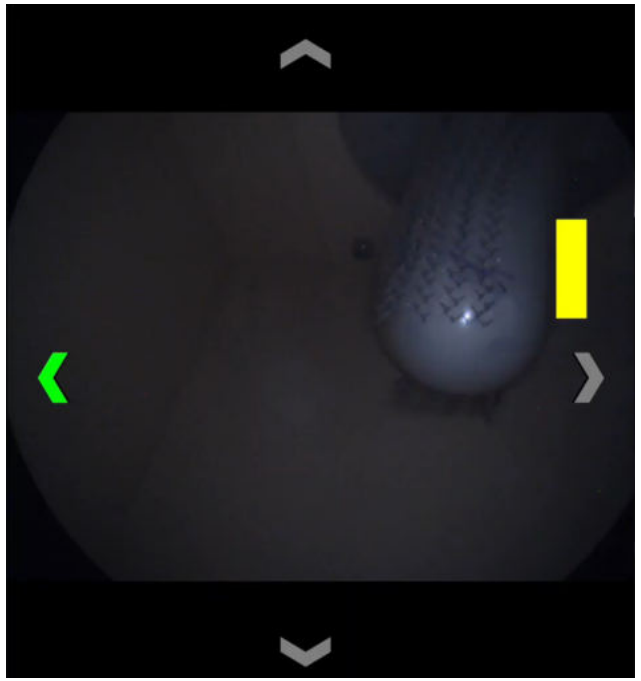


Comanipulation



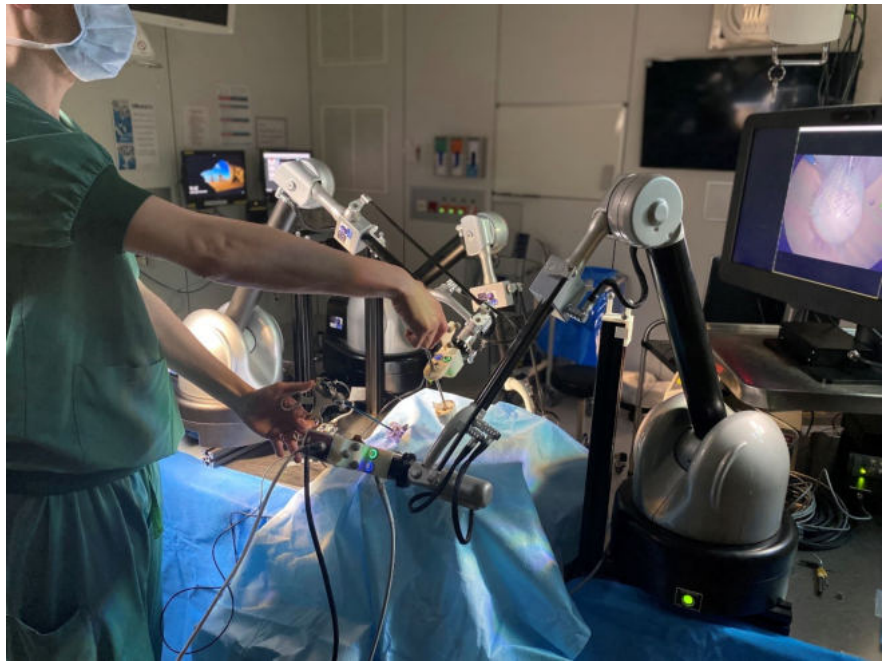
Comanipulation with visual guidance



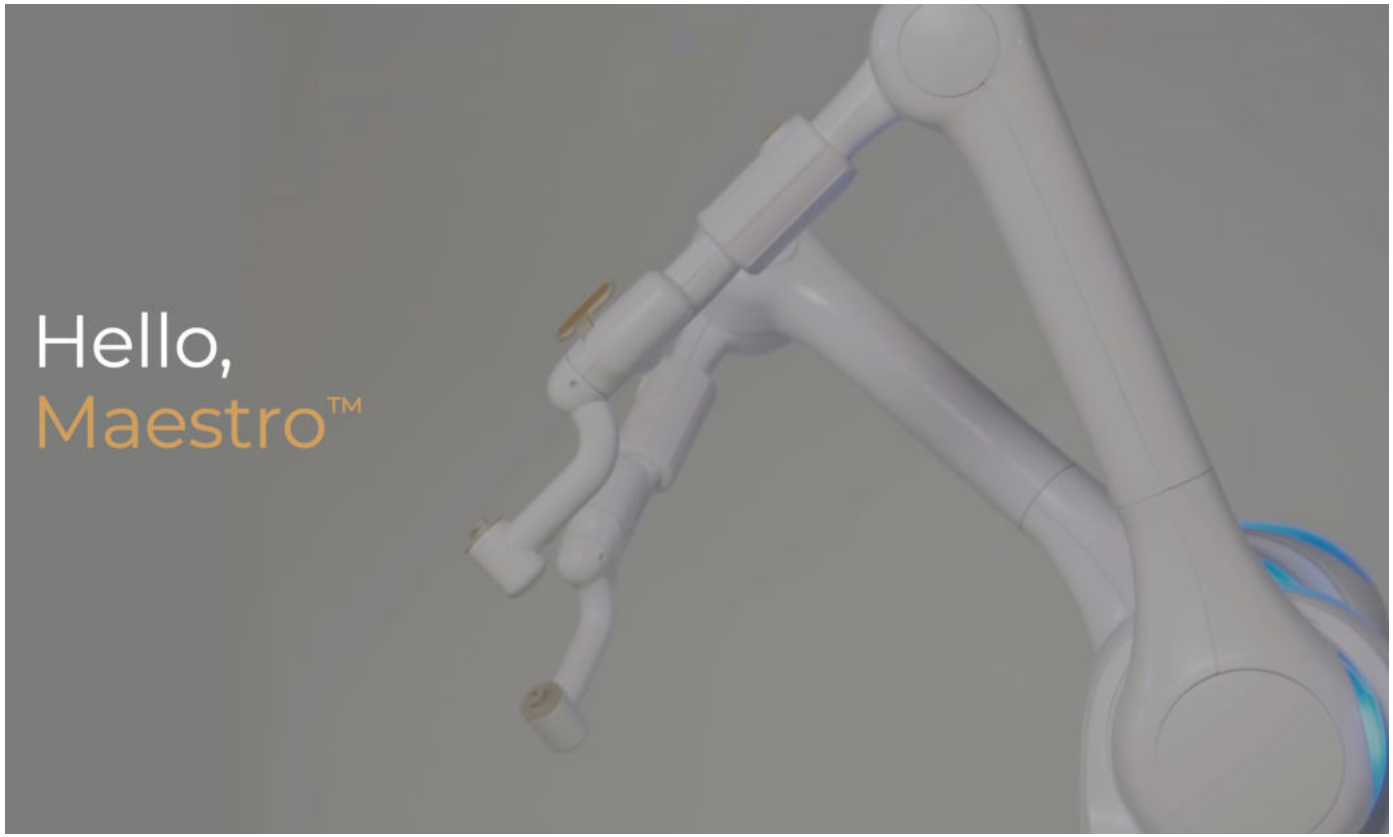


Comanipulation with visual guidance

		Time [min]	Sutures	Score	Force [N] Mean	Force [N] Max
M	P1	25.0	2	3	6.69	13.76
	P2	25.0	5	6	6.29	10.88
	P3	25.0	7	8	4.74	11.69
	P4	22.86	8	9	4.66	9.81
	P5	25.0	4	5	7.04	15.02
	P6	25.0	7	7	6.37	13.29
	P7	25.0	7	8	8.88	18.22
	P8	19.82	8	10	4.43	7.09
	P9	23.02	8	10	4.29	13.34
	P10	25.0	4	4	4.98	9.21
		24.07 ± 1.63	6.0 ± 2.00	7.0 ± 2.32	5.84 ± 1.40	12.23 ± 3.03
R	P1	25.0	3	2	7.51	9.37
	P2	25.0	2	2	7.44	9.73
	P3	22.35	8	10	6.16	8.31
	P4	24.05	8	9	6.31	9.05
	P5	25.0	4	4	4.25	10.93
	P6	25.0	4	5	6.07	8.65
	P7	21.54	8	9	6.80	8.73
	P8	20.75	8	10	1.73	6.38
	P9	23.76	8	9	7.16	11.90
	P10	25.0	1	1	7.32	9.55
		23.75 ± 1.54	5.4 ± 2.73	6.1 ± 3.48	6.08 ± 1.72	9.26 ± 1.41
p-value		$0.49^{\ddagger}$	$0.60^{\dagger}$	$0.53^{\dagger}$	$0.47^{\ddagger}$	$0.02^{\dagger,*}$



Moon Surgical



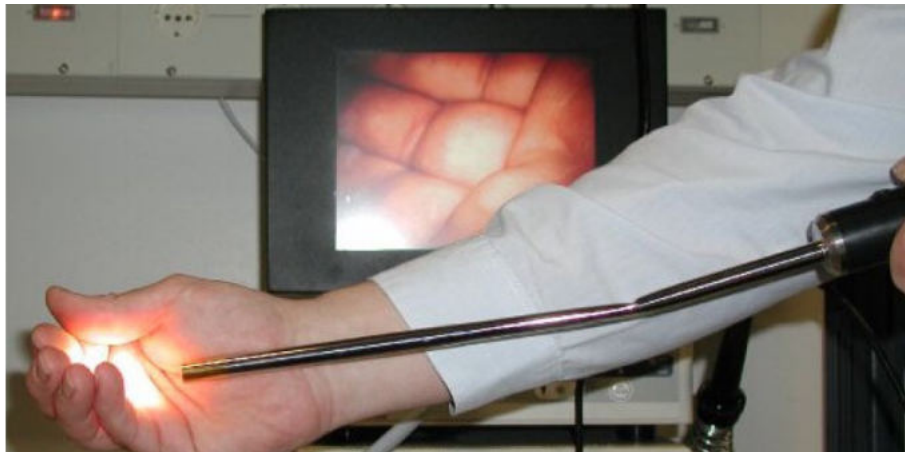
https://moonsurgical.com/maestro-system

KU LEUVEN

Reduced Invasiveness

Recent Evolutions

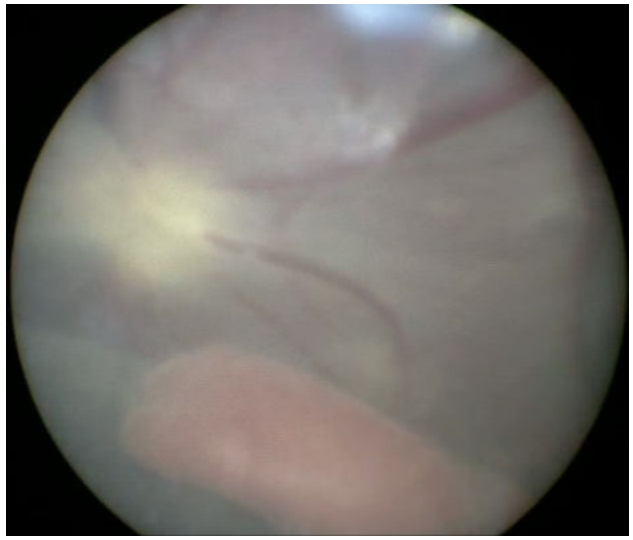
Recall …



increased levels of **trocar site hernia** when operating laparoscopically or robotically [1-3]

[1] F. Helgstrand et al., "Trocar site hernia after laparoscopic surgery: a qualitative systematic review," Hernia (15), 2, pp.113–121, Apr. 2011.
[2] H. A. Swank et al. , "Systematic review of trocar-site hernia," Br. J. Surg., vol. 99, no. 3, pp. 315–323, Mar. 2012.
[3] G. Scozzari et al., "High incidence of TSH after laparoscopic or robotic Roux-en-Y gastric bypass," Surg. Endosc, 28(10)p.2890–2898, 2014.

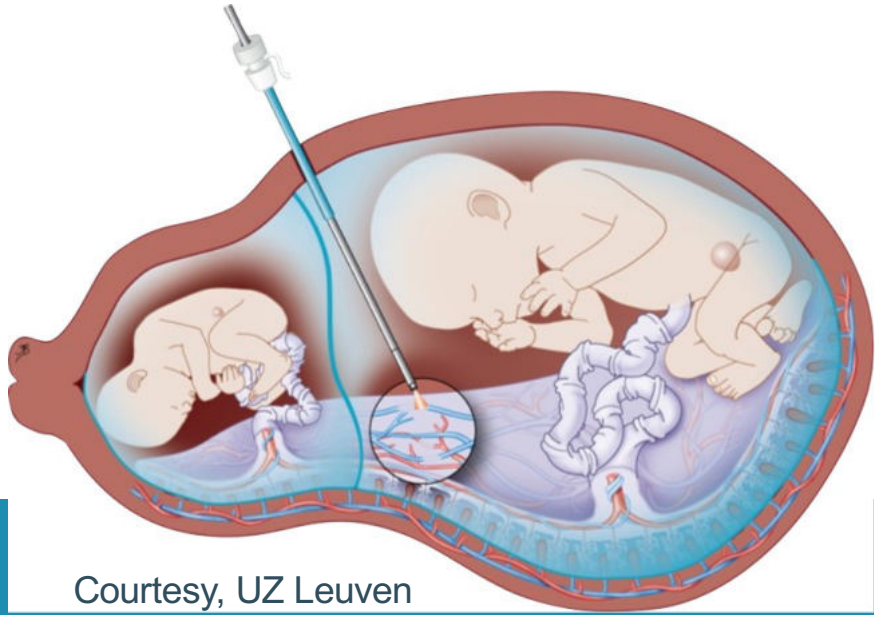
Minimal invasive Fetal Surgery



Success is relative !

Stiff instruments & large forces
18.5 % rupture of membranes

Fetoscopic Laser Photocoagulation
treatment success
close to 100 %

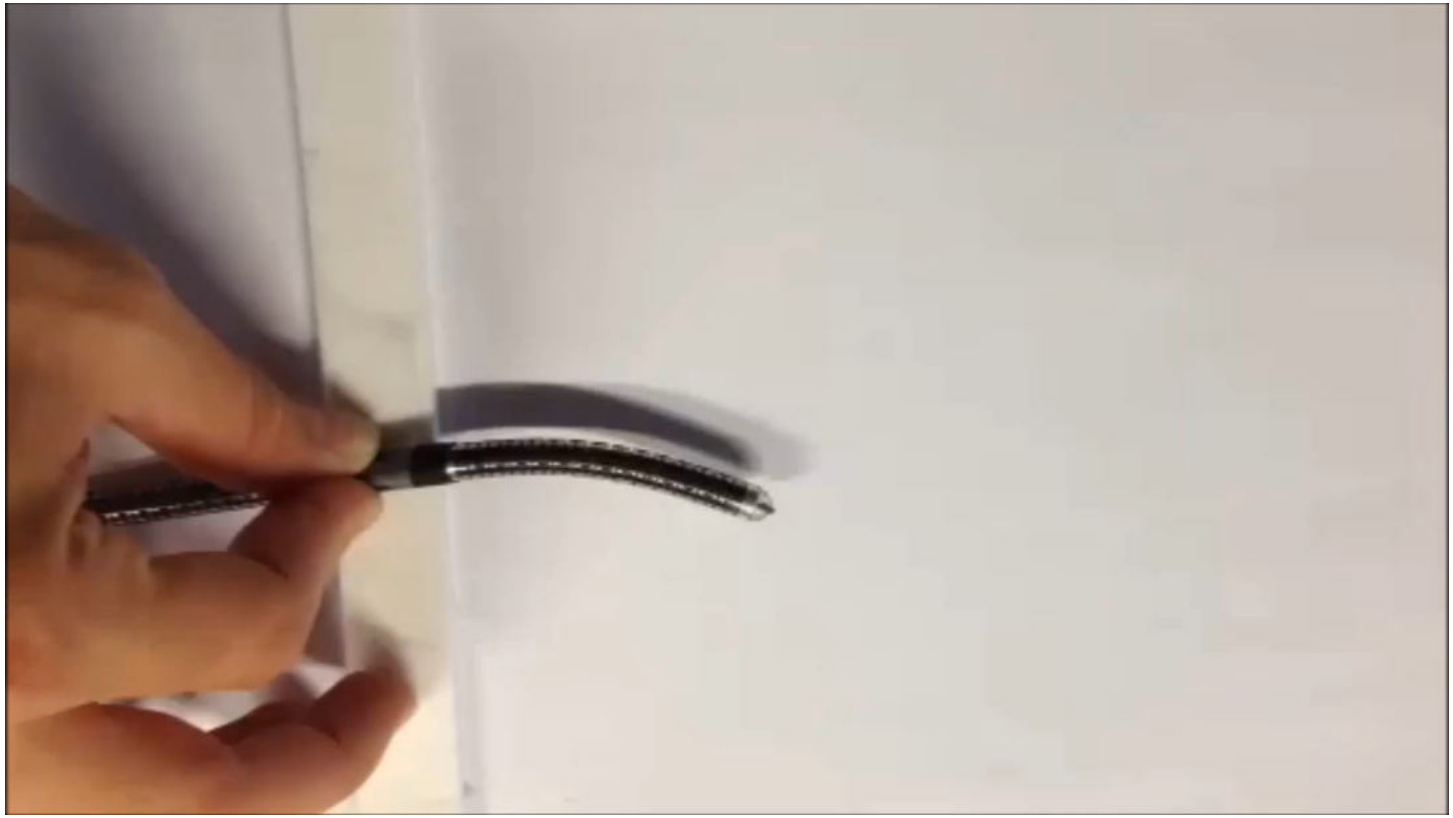


Courtesy, UZ Leuven

L. Maggio et al., “Iatrogenic preterm premature rupture of membranes after fetoscopic laser ablative surgery,” Fetal Diagn Ther., 38(1), pp. 29–34, 2015.

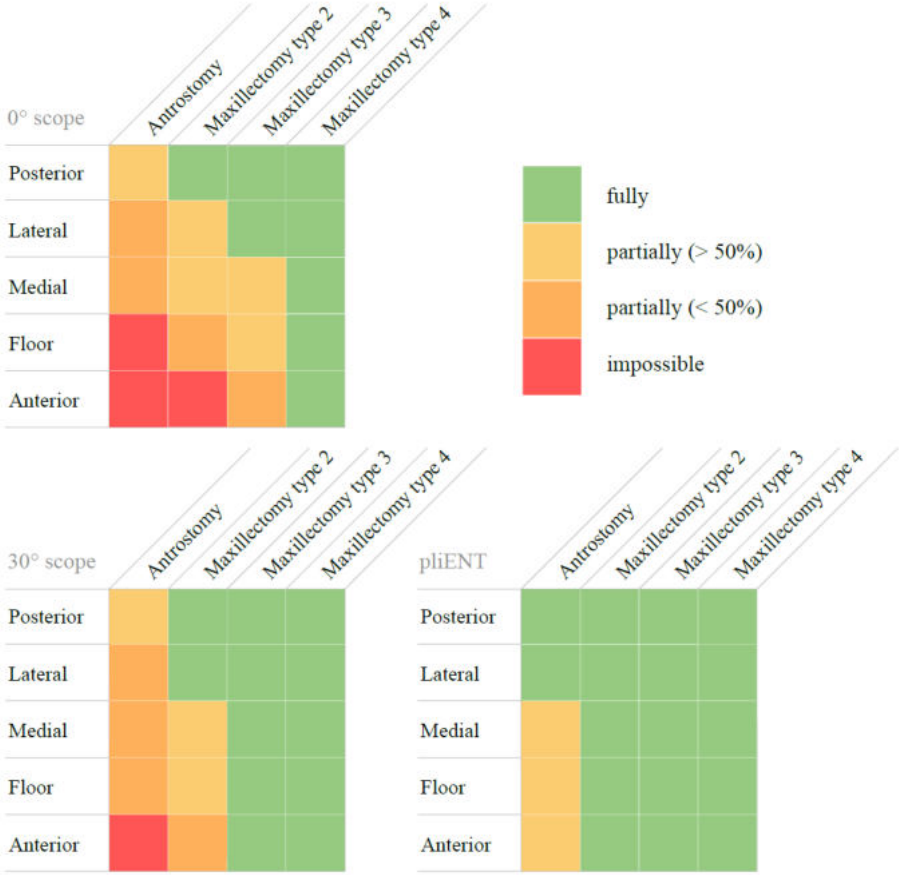
Intrinsic safety

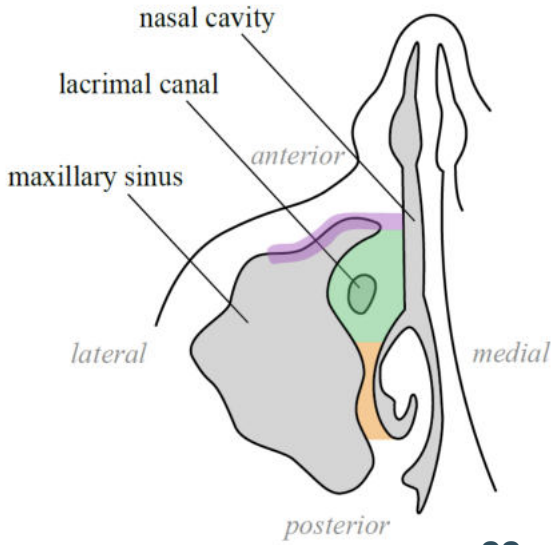
Steerable instruments



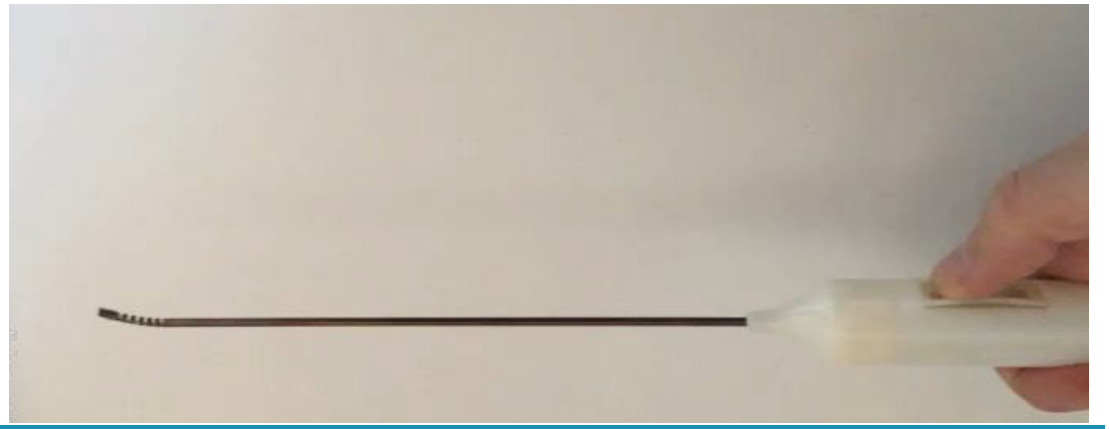

Plasmalyte

Navigate confined spaces





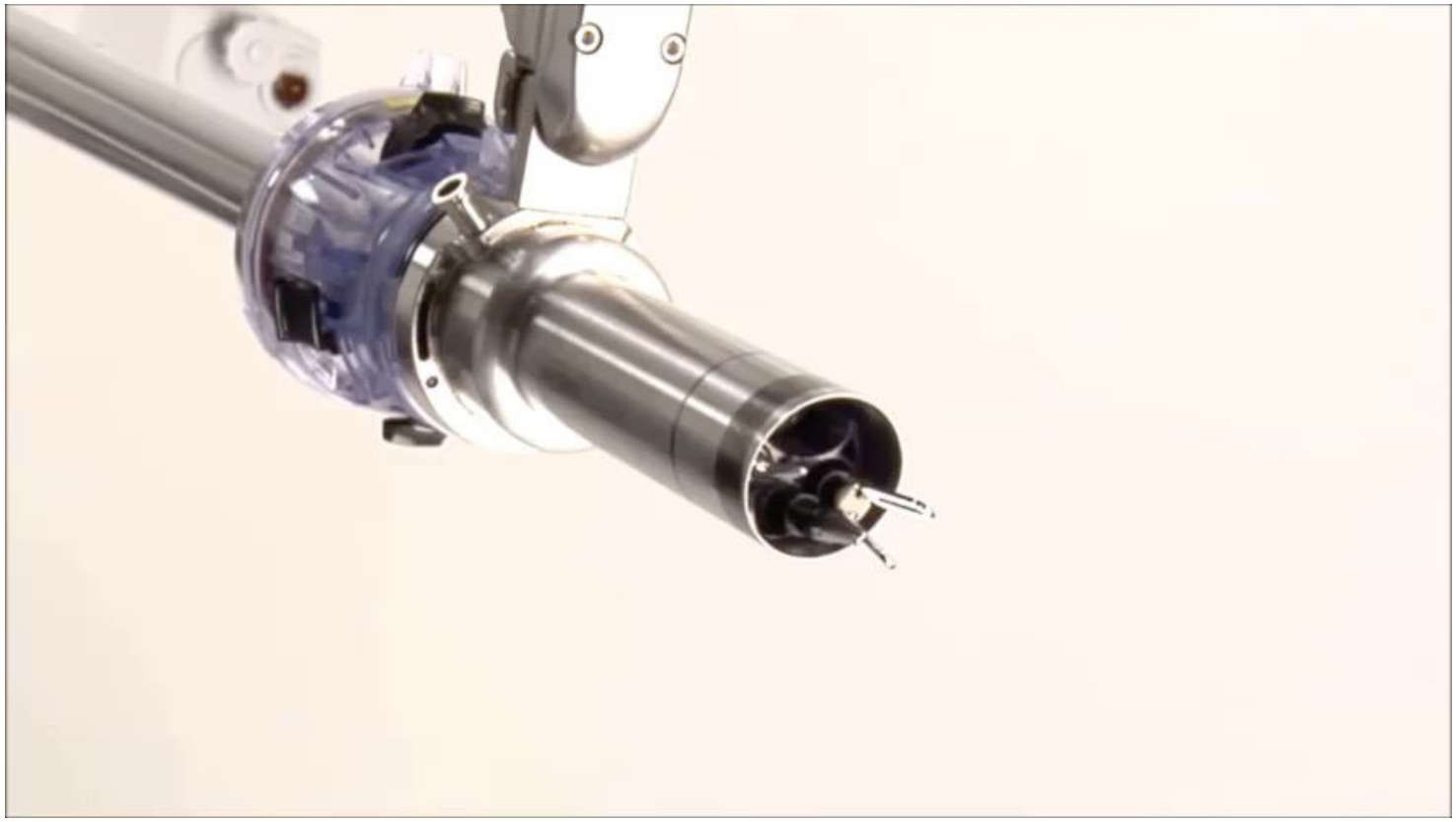
2.3 mm **22 mm**



J. Legrand, A miniature robotic steerable endoscope for maxillary sinus surgery called PliENT. Scientific Reports, 12, Art.No. 2299. doi:10.1038/s41598-022-05963-3

Multi-arm robotic systems

SP 1098



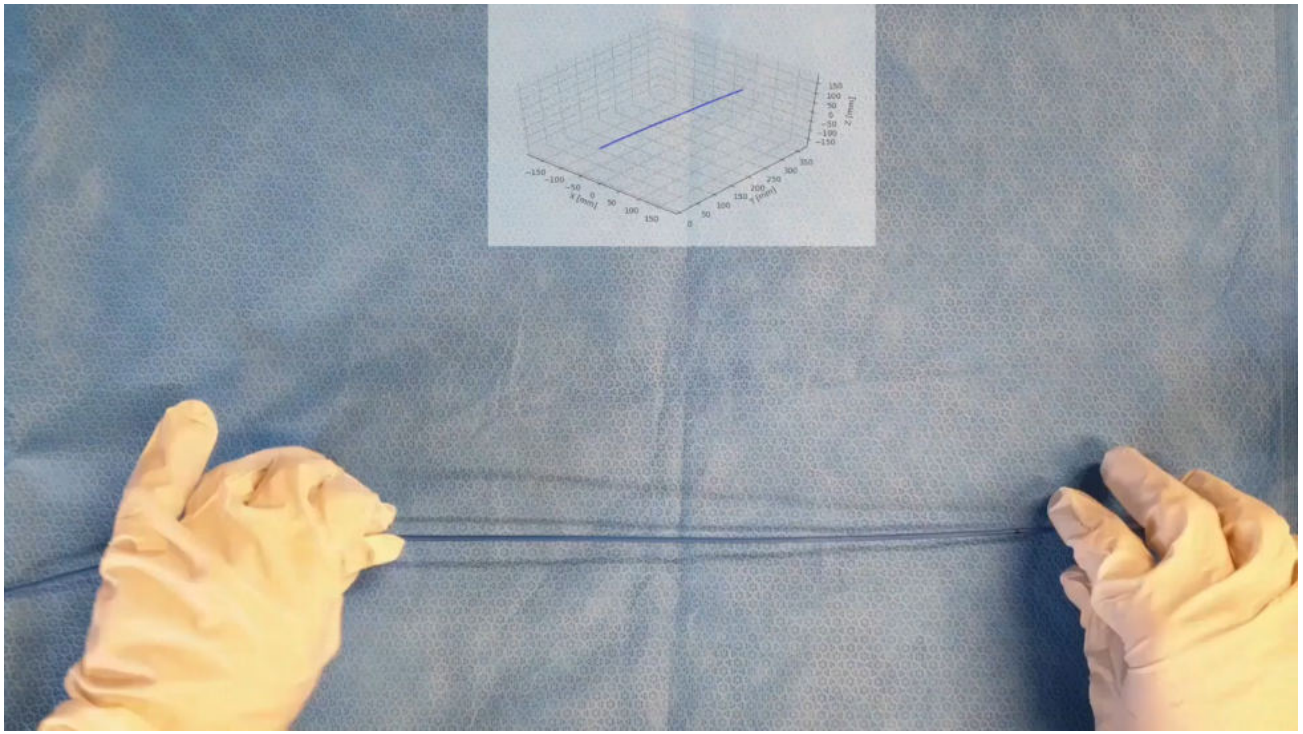
KU LEUVEN

Improved Awareness

Recent Evolutions

Integrated sensing

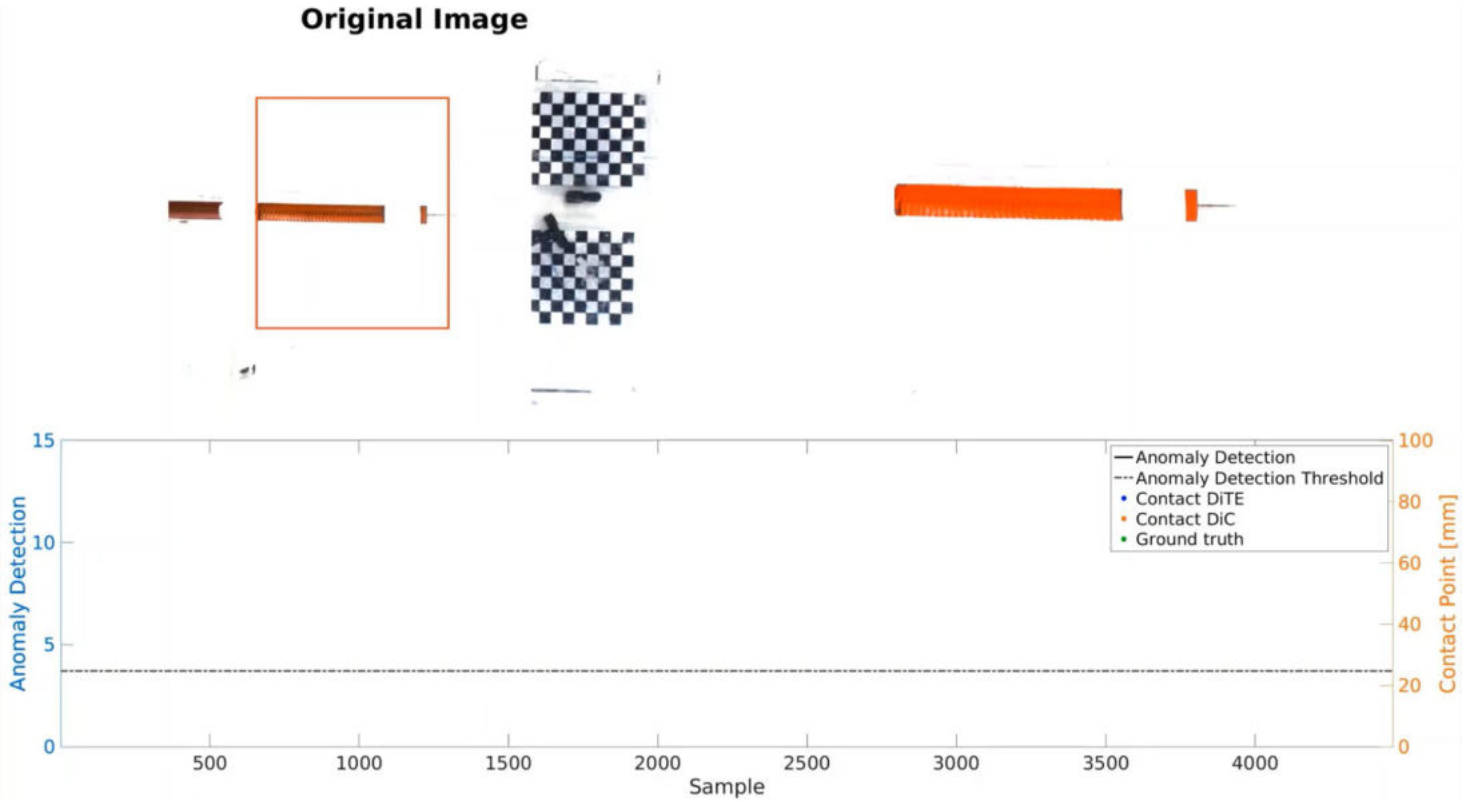
shape sensing



Al-Ahmad, et al. (2020). Improved FBG-Based Shape Sensing Methods for Vascular Catheterization Treatment. RA-L, 5 (3), 4687-4694. doi: 10.1109/LRA.2020.3003291

Integrated sensing

distributed force sensing



HA, X.T., Wu, D., Lai, C-F., Ourak, M., Borghesan, G., Menciassi, A., Vander Poorten, E. with Wu, D. (corresp. author) (2022). Contact Localization of Continuum and Flexible Robot Using Data-driven Approach. IEEE Robotics and Automation Letters. doi: 10.1109/LRA.2022.3176723

KU LEUVEN

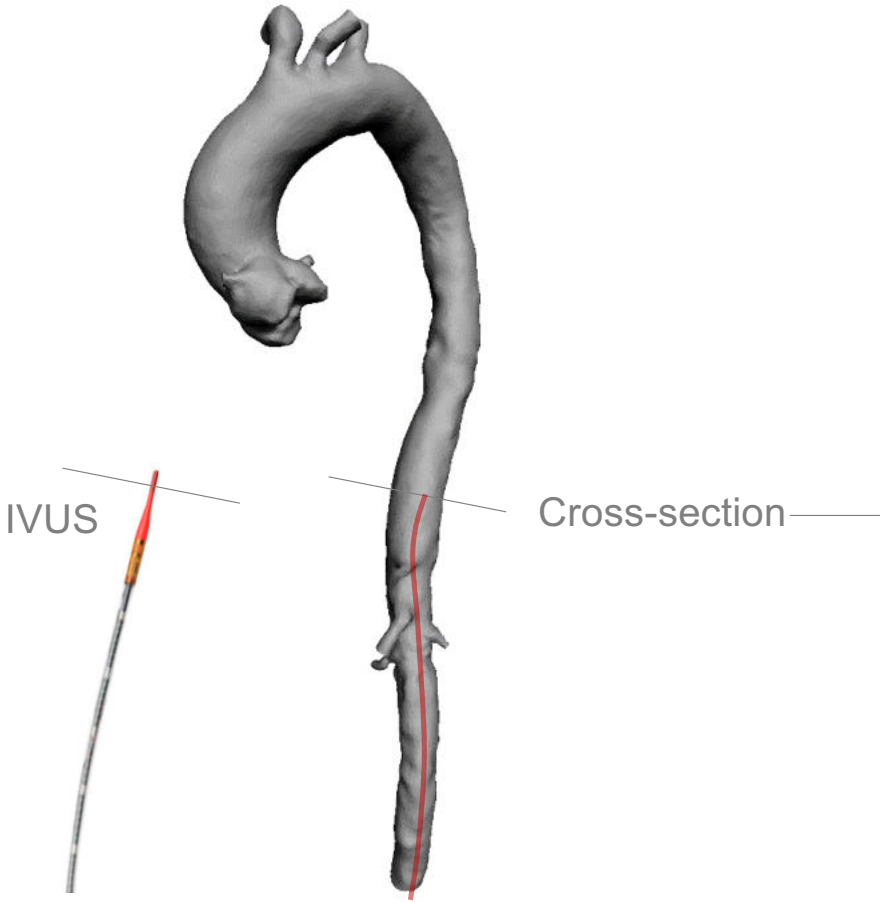
Improved Intuitiveness

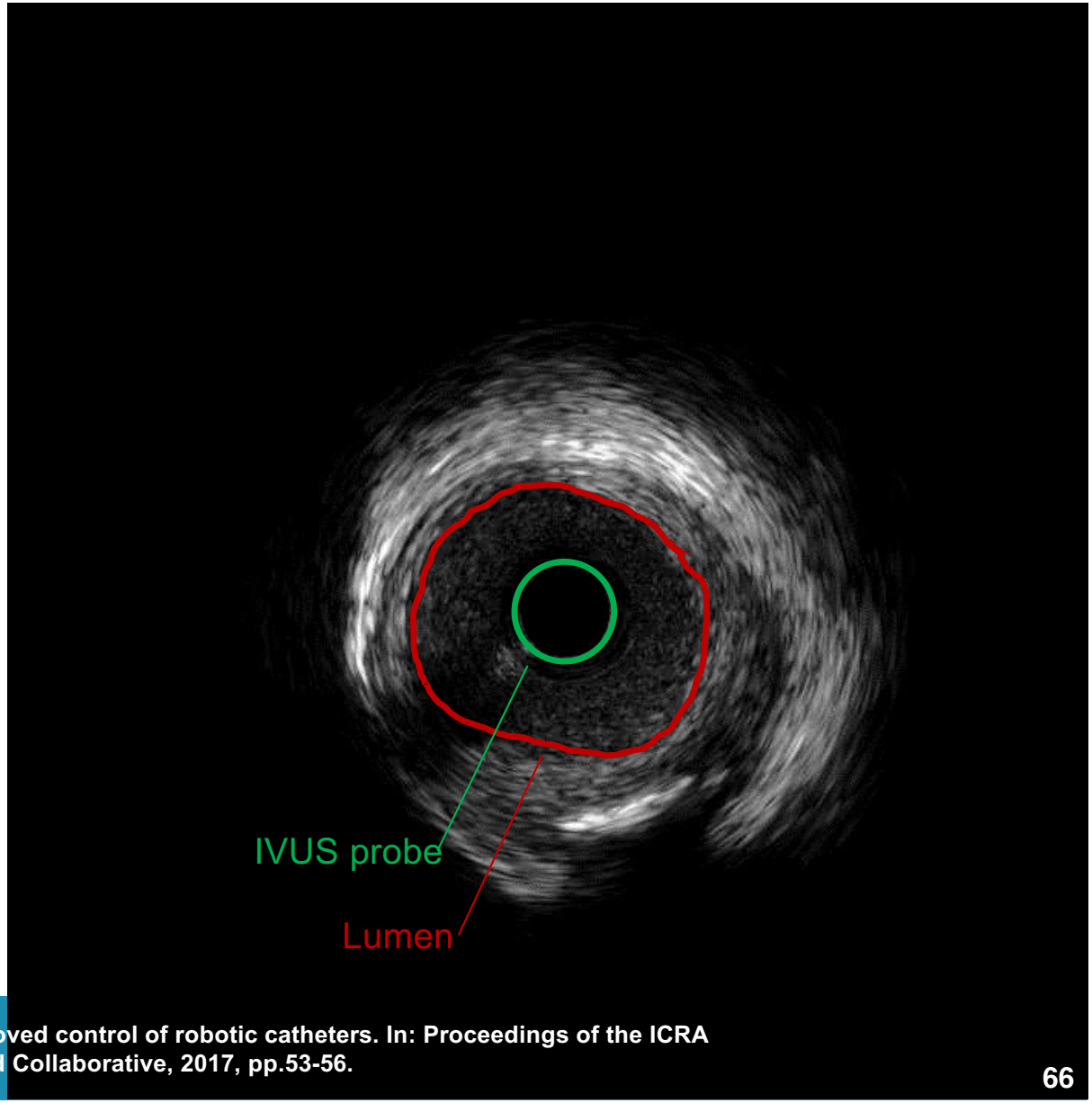
Recent Evolutions

Shared Autonomy

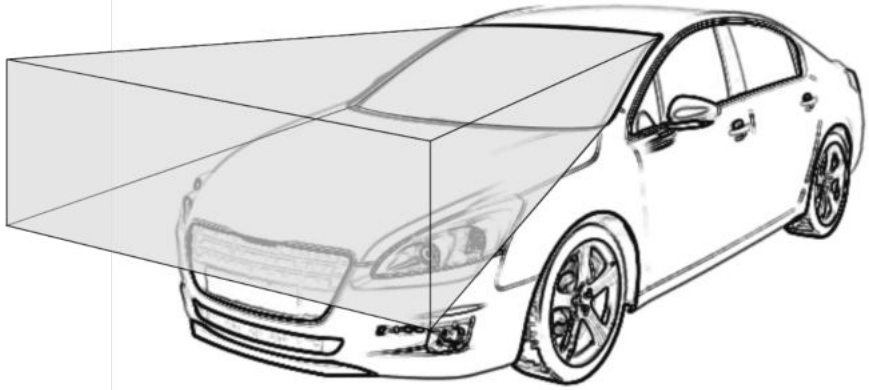
navigation assistance

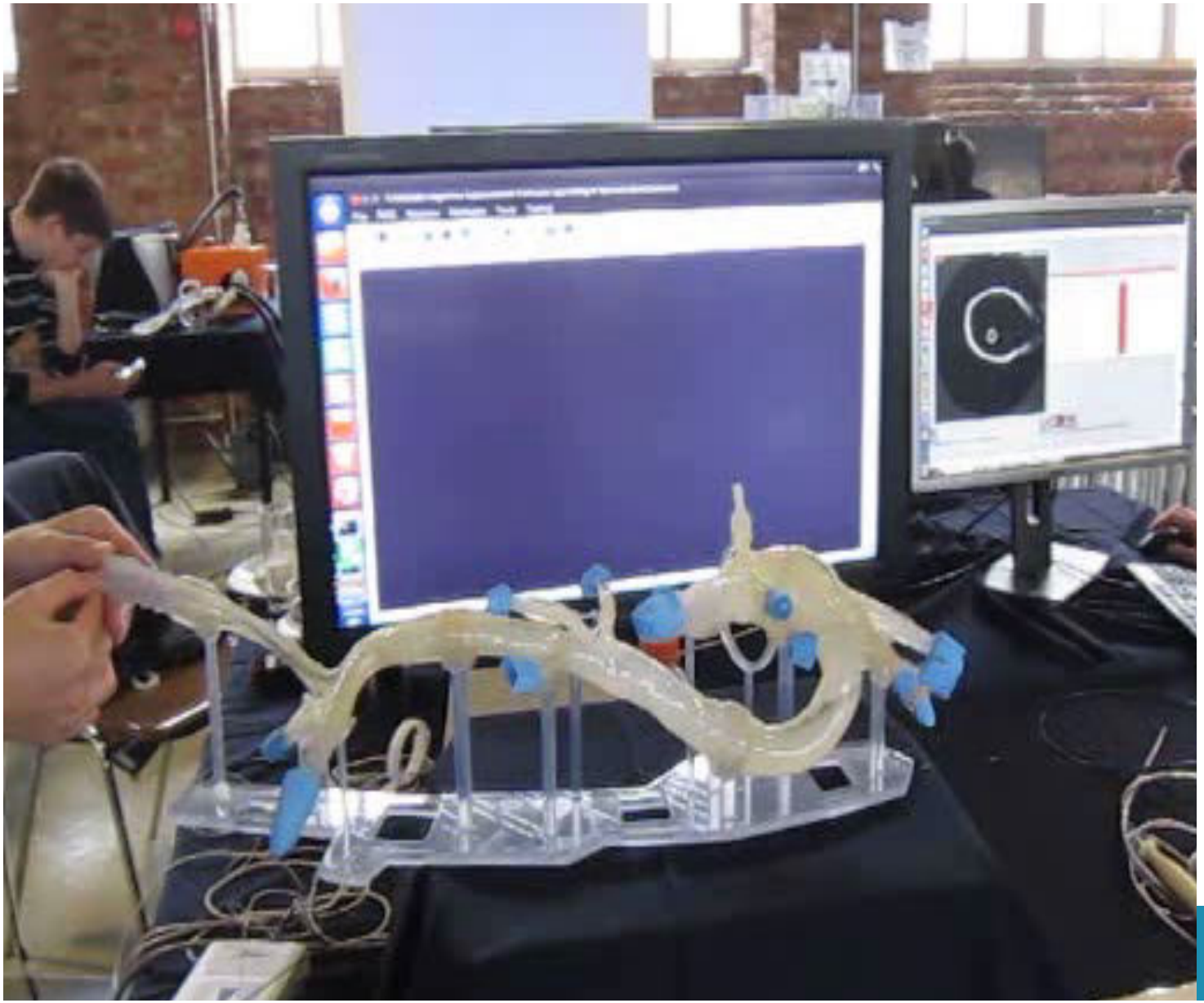
Vessel reconstruction





Tran PT., *et al.* IVUS-based local estimation of vessel geometry for improved control of robotic catheters. In: Proceedings of the ICRA workshop on C4 Surgical Robots: Compliant, Continuum, Cognitive and Collaborative, 2017, pp.53-56.



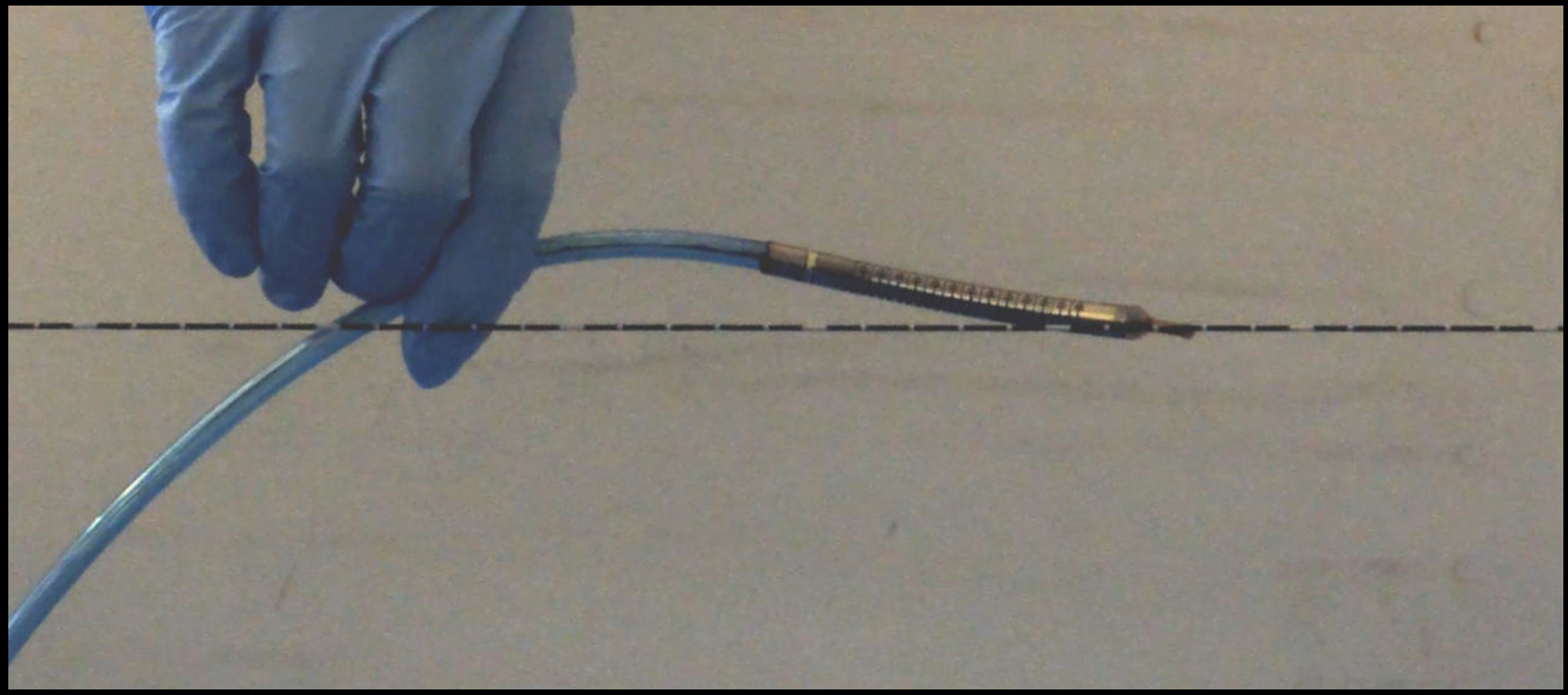


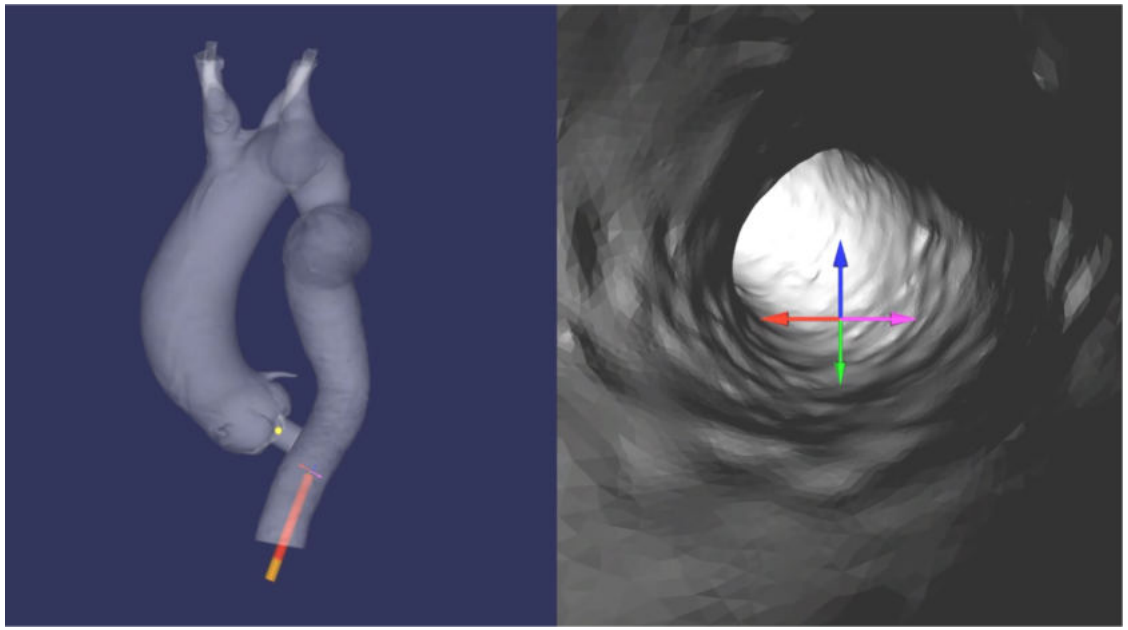
Imperial College London

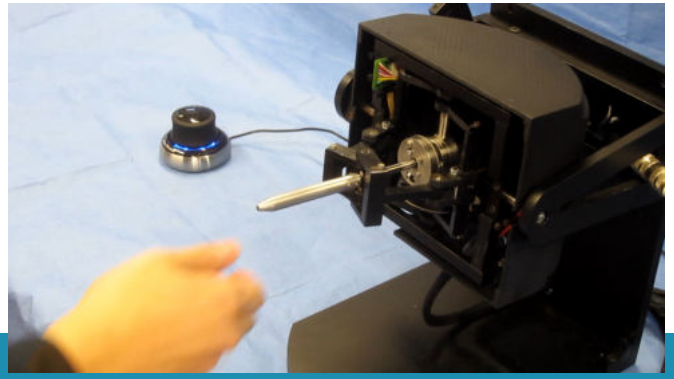
The Hamlyn Centre for Robotic Surgery

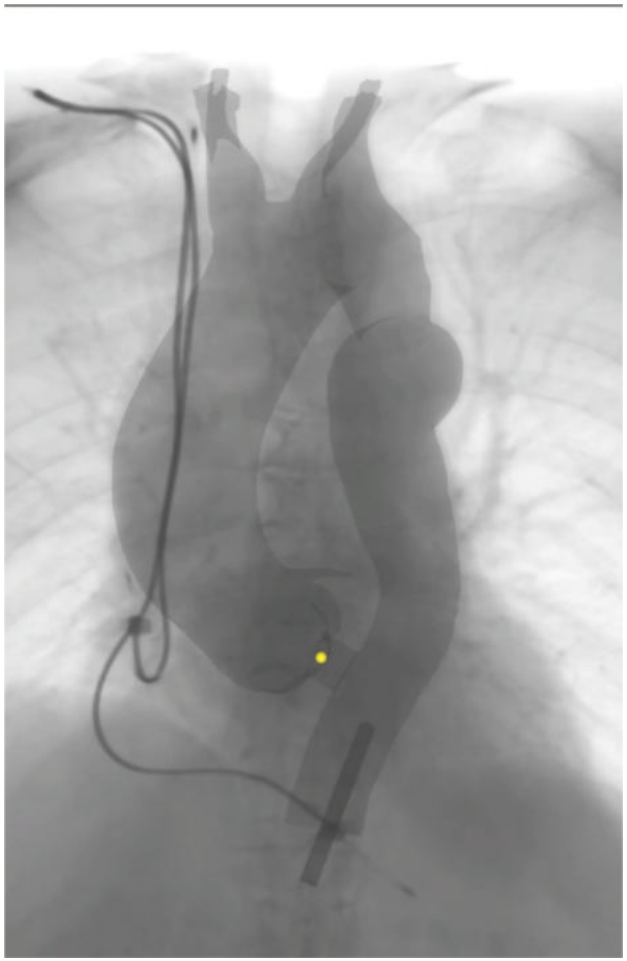
Materialise
innovators you can count on

L. Zhao *et al.*, "SCEM+: Real-Time Robust Simultaneous Catheter and Environment Modeling for Endovascular Navigation", RAL 2016, 1(2), pp.961-968









Trends

- improved ergonomy, lower learning curves
- new treatment approaches
- new sensors
- new interfaces
- autonomy

- new therapies