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EDITORIAL

# Robotic assistance and its impact on vitreoretinal surgery

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**ABSTRACT**
Technological advances in mechatronics makes robotics possible, in vitreoretinal surgery as in other ophthalmic disciplines. With the arrival of the first systems in clinical use, a path forward has been defined which outlines both benefits and hurdles to be overcome.

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Robotics; micromanipulation; OCT guidance; vitreoretinal surgery

## 1. Introduction

Technology has always underscored major innovations in ophthalmology whether diagnostic or surgical. In this respect robotics or more precisely microrobotics is the latest chapter of this long tradition. In general surgery, robotics has been used for more than 20 years, and while a commercial solution in ophthalmology has only recently been proposed, research in the field has been ongoing over the same period of time. The specific requirements for ophthalmology are complex. Ocular tissues are particularly fragile and the margin of safety limited, hence the constraints on precision are in the order of micrometers; orientation occurs in a limited three dimensional space where fixed fragile boundaries such as the retina require highly accurate movements with no overshoot. High accuracy and precision are required at the site of surgery, but it should not impair rapid movement elsewhere. Safety concerns often raised regarding inadvertent ocular movements must be accounted for in the proposed robotic design and the platforms that support them. The system must access the eye through a limited surface area while having minimal impact on the intraocular reach and range of instruments. These engineering challenges are being met by the current generations of micro manipulators. They fall into 3 major designs: instrument enhancement and stabilization, co-manipulation which guides and constrains the surgeon to specific actions or tasks, and telemanipulation in which procedures are enhanced by computer modulation [1].

## 2. Challenges and opportunities

Beyond technological feats, lies the challenge of benefit and adoption. New technologies inspire awe but also skepticism. How should they be integrated in established standards of care? Where can they add benefit? Are they as safe as current techniques? Early surgical robots required dedicated operating suites that were difficult to adapt to any other use, and at a high initiation cost. Current designs call for a more modular construct that can be integrated in existing operating rooms (OR) with a minimal footprints. Capital costs are aligned with existing costs for OR equipment. Current designs allow for hybrid surgery where the surgeon uses robotics to enhance his surgical abilities when needed but carries out surgery using a conventional approach when it is either time efficient or perceived as superior in an individual surgeon's hand [2]. Adoption of new technology is a decade long process, one during which it must identify those applications where it can itself or in combination with other technologies provide benefit [3]. For robotics to have a significant impact on vitreoretinal surgery three specific developments are required: [1] combining enhanced tissue visualization with high precision robotics; [2] procedures that can only be made safe, reproducible and standardized by the use of high precision devices; [3] developing robocentric procedures and automation.

Introduced about 10 years ago, intraoperative optical coherence tomography (iOCT) provides high resolution retinal imagery, allowing surgeons to determine the adequacy of surgical tasks. However, this subjective assessment requires a temporary pause in the conduct of surgery. Maintaining an overview of a surgical field while focussing on a high resolution screen is a complex visual task best approached by alternating from one visual focus to another. A challenge in a static task, difficult if not impossible to reconcile in a dynamic environment. However, for a robotic system, operating within the confines of a plane 10 µm or less, this is eminently possible under both circumstances and using existing iOCT microscopes, making real-time iOCT guided surgery a reality for all surgeons. Experimental systems that incorporate an OCT machine were shown to be safe, fast and capable of performing fully automated phacoemulsification [4,5]. From a robotic standpoint, vision is required at the instrument tip. As long as it is capable of assessing the tissue planes present in front of itself over a limited visualization angle, peeling, dissection or piercing would be possible -faster and safer than can be currently carried out [6]. Surgical procedures are highly variable. The evolution of cataract surgery and phacoemulsification has shown that with appropriate engineering, that variability can be eliminated.

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Robotics allows one to dissect each surgical procedures into its intrinsic steps and engineer out variability. Surgical standardization provides several benefits – rapid assessment of procedures and their validity, elimination of complications, rapid introduction and dissemination, and most important a limited learning curve for surgeons at all levels of experience. Simulators have shown both in ophthalmology and beyond, that robotics levels the playing field between experienced and novice surgeons [7,8]. Gene therapy, a highly priced, immunogenic product, which requires delivery to the subretinal space without reflux or breech of Bruch's membrane, using a slow infusion over several minutes can be done safely, and reproducibly using robotics. Indeed, robotics allows for a careful determination of the optimal delivery technique, adapted to each retinal pathology. A level of precision which to date has eluded most surgeons. With micrometer precision and accuracy, novel surgical approaches can be envisioned: cannulation of venules and arterioles, microinvasive site directed vitrectomies, single cell transfections [9].

The impact is of course not limited to the realm of vitreoretinal surgery but can be expanded to other branches of ophthalmology – glaucoma stent insertion, refractive and cataract surgery. However, in areas where procedures are intrinsically efficient and safe, full automation will be required to justify the required investments in technology. Automation does not eliminate the role of surgeons, as some have hoped and others feared. If one considers the evolution of laser refractive surgery, despite high levels of automation, surgical skill still remains central to success. Skill in developing, testing and refining techniques, but also with the help of artificial intelligence, honing in on the best approach in countless situations that simply cannot be predicted by careful engineering alone. Data mining recordings of surgical procedures which include the movements performed by the robot as well as information provided by imaging modalities will help provide surgeons with best practice options as they perform their surgery. This will necessitate finding the appropriate haptic, auditory or visual feedback, and will probably vary with each situation and each individual.

## 3. Conclusion

Robotics is here, now, and in an appropriate form for eye surgery. While it may currently have difficulty competing with existing, efficient manual surgical techniques, early adopters will start to think and implement robocentric procedures, that expand beyond what is currently possible. As data emerges on the benefits in outcomes both short and long term from the use of high precision micromanipulators, there will be more and more demand from physicians and the public for the use of these devices. How rapidly adoption will occur is difficult to say, but there is a sense of inevitability that only time can define the exact course.

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## Declaration of interest

Marc D. de Smet is a co-founder, employee and patent holder of Preceyes BV. The author has no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

## Reviewer Disclosures

A reviewer has disclosed they have several patents through UCLAS on the topic of eye robotic systems. Peer reviewers on this manuscript have no other relevant financial relationships or otherwise to disclose.

## References

Papers of special note have been highlighted as either of interest (•) or of considerable interest (••) to readers.

1. de Smet MD, Naus GJL, Faridpooya K, et al. Robotic-assisted surgery in ophthalmology. Curr Opin Ophthalmol. 2018;29(3):248–253.
2. Edwards TL, Xue K, Meenink HCM, et al. First-in-human study of the safety and viability of intraocular robotic surgery. Nat Biomed Eng. 2018;2:649–656.
   - **First report of in human use of a robotic arm to carry out vitreoretinal surgery. The robotic arm caused less superficial hemorrhaging than with conventional surgery.**
3. Brynjolfsson E, McAfee A. The second machine age. New York: W.W. Norton & Company, Inc; 2014.
4. Chen CW, Francone AA, Gerber MJ, et al. Semiautomated optical coherence tomography-guided robotic surgery for porcine lens removal. J Cataract Refract Surg. 2019;45(11): 1665–1669.
   - **Provides a state of the art overview of real-time OCT integration in an surgical cataract platform as well as some of the current challenges**
5. Chen CW, Lee YH, Gerber MJ, et al. Intraocular robotic interventional surgical system (IRISS): semi-automated OCT-guided cataract removal. Int J Med Robot. 2018;14(6):e1949.
6. van Romunde S, Faridpooya K, Vermeer KA, et al. Evaluation of OCT versus surgeon guided robotic manipulation in a simulated vitreoretinal model. Invest Ophthalmol Vis Sci. 2018;59(9):5930(abstract).
7. Maberley DAL, Beelen M, Smit J, et al. A comparison of robotic and manual surgery for internal limiting membrane peeling. Graefes Arch Clin Exp Ophthalmol. 2020;258(4):773–778.
8. Forslund Jacobsen M, Konge L, Alberti M, et al. Robot assisted vitreoretinal surgery improved surgical accuracy compared with manual surgery: a randomized trial in a simulated setting. Retina. 2019. DOI:10.1097/IAE.0000000000002720.
   - •• **In a controlled simulation assessed the performance of experienced and novice vitreoretinal surgeons and assessed the benefits and limitations of robotic assistance in both groups.**
9. de Smet MD, Stassen JM, Meenink TC, et al. Release of experimental retinal vein occlusions by direct intraluminal injection of ocriplasmin. Br J Ophthalmol. 100(12): 1742–1746. 2016. .
   - **An example of a surgical procedure, the cannulation of small branch retinal veins which is beyond the capabilities of a standard vitreoretinal surgeon, but well within the reach of robotics.**