Recent Advancements in Vitreoretinal Techniques – A Critical Reappraisal

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Abstract

The purpose of this review is to stimulate a debate and doubts about future trends in vitreoretinal surgery and social and economic implications. We want to share with our colleagues the challenges of modern ophthalmic surgery in the era of technocratic medicine with the goal to conjugate the technological progress with economic sustainability and equity of access to health facilities and services. The increased possibilities provided by technology result in an increased responsibility. That is, there is no technological imperative, but technology promotes a moral imperative; in particular, it promotes a moral imperative to proper assessment. We offer a historical and economic reappraisal of recent advancements in vitreoretinal surgery since 2002 to today's state of the art in macular surgery and retinal detachment surgery.

Keywords

Small-gauge vitrectomy, 25-gauge vitrectomy, 23-gauge vitrectomy, 27-gauge vitrectomy, Health Technology Assessment, technocratic medicine, technological imperative, historical perspective, macular surgery, retinal detachment surgery, scleral buckle, dye-assisted vitrectomy, macular holes, macular epiretinal membrane

Disclosure: Andrea Grosso, Luis Arias, Cesare Mariotti, Francesco Faraldi, Claudio Panico and Marta Figueroa have no conflicts of interest to declare. No funding was received for the publication of this article.

Acknowledgements: Andrea Grosso is grateful to Professor Hugh R Taylor AC, Harold Mitchell Chair of Indigenous Eye Health and Deputy Head, Melbourne School of Population and Global Health, former Managing Director of the Centre for Eye Research Australia, University of Melbourne, his mentor during his retinal fellowship in Melbourne in 2006, for his critical comments about the manuscript and his lesson to think about the social and economic implications of eye diseases. The authors are indebted to Dr Carlos Mateo, vitreoretinal surgeon, founding member of the Ocular Microsurgery Institute of Barcelona, Associate Professor of Ophthalmology at the Autonomous University of Barcelona. We appreciate his open mind, his sincere and pragmatic approach in vitreoretinal surgery and kind support in reviewing this manuscript. Andrea Grosso is grateful to Roberta Siliquini, Professor of Public Health in Torino for the discussion around the technocratic model of medicine and the technological imperative in eye care. Andrea Grosso also acknowledges Dr Boon Kwang, Singapore National Eye Centre and Singapore Eye Research Institute (SERI), for sharing personal surgical experiences during his stage in January 2013. To his friends Mario Romano, Guido Prigione, Matteo Cereda, Piero Ceruti, brilliant young vitreoretinal surgeons for the day-by-day exchange of experience, frustrations and perspectives around the future trends of vitreoretinal surgery.

Received: 24 February 2014 **Accepted**: 6 May 2014 **Citation**: *European Ophthalmic Review*, 2014;8(1):46–52 *DOI: 10.17925/EOR.2014.08.01.46*

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The psychosocial impact of sight disorders in modern society is very high, since most information and sociocultural activities use visual function as their primary system. Even moderate reduction in vision prevents people from enjoying healthy and independent ageing and has a devastating impact on both an individual's occupational life and on sociocultural activities.[1–5]

In parallel, the technological improvement has been extensive in recent years and has even allowed customised surgical solutions.[6] The small-gauge sutureless transconjunctival surgery, also known as minimally invasive vitreous surgery (MIVS) or microincision vitrectomy, is a classic example of progress in biomedical engineering.[7] This system allows three-port pars plana vitrectomy (PPV) using microcannulas, trocars and lower than 20-gauge instrumentation without requiring sutures to close the sclerotomies. The gauge of trocars are differentiated as 23- (0.64 mm), 25- (0.51 mm) and 27- (0.40 mm) gauge techniques.[7–9] As a result, more accurate and reliable results (peripheral vitreous shaving, better control of duty cycles in the vitrectomy platforms) were made possible. The advantage over larger gauge procedures comes primarily from reduced postoperative inflammation at the sclerotomy site and reduced manipulation of periocular tissues, leading to speedier recovery and decreased rate of surgical complications.[10] Furthermore, the reduced operating time decreases costs, and the small incisions are especially appropriate for working on the eyes of children. Although originally used for macular diseases, 23- and 25-gauge surgeries have progressed so much in recent years that they are the approach-of-choice for most vitreoretinal procedures. Most complications are centred on wound stability and risk of postoperative hypotony, endophthalmitis and port site retinal break formation.[11–13] The wound architecture is now improved by new trocar blade design. Depending on the type of surgery (retinal detachment surgery or macular surgery) the vitrectomy may be complete or partial (also known as 'core' vitrectomy or minimal vitrectomy), respectively. In the core vitrectomy the surgeon cleans only the central vitreous paying attention to the periphery, even though no shaving of the peripheral vitreous and no laser are used. The technological progress has made it possible to combine MIVS and phacoemulsification with intraocular lens (IOL) implantation in the same surgical session.[14–17] It is well known that vitrectomy may induce cataract, especially in eyes in which an internal tamponade is introduced. There are several advantages offered by the combination of phacoemulsification and vitrectomy into one procedure. However, this surgical option varies across different countries according to different national health insurance systems.

Modern medicine carries the risk of being 'technocratic', commercially orientated and not economically sustainable for national health systems. We need to find a compromise between technological innovation, achievements of durable functional results for patients and economic sustainability. Today economic reports about the impact and costs of visual loss and population-based evidence about the prevalence of disability from eye diseases are available to direct our interventions and preventive measures.[18–24]

Historical Perspective

Head-to-head 25-gauge Vitrectomy versus 23-gauge Vitrectomy and the Reasons for the Diffusion of the 23-gauge Technique (2002–2005)

Following similar trends of smaller instrumentation in phacoemulsification in the anterior segment world, the evolution of vitrectomy surgical techniques had an exciting advance with the introduction of 25- and 23-gauge transconjunctival small-gauge instrumentation for macular surgery. In 1990, Eugene de Juan developed 25-gauge instruments, but the 25-gauge transconjunctival sutureless vitrectomy was not introduced until 2002 by GY Fuji.[25,26] Sharing characteristics of both its forerunners, 23-gauge vitrectomy soon followed, developed by Claus Eckardt in 2005.[27] It was smaller than 20-gauge but more rigid than 25-gauge, making procedures such as endolaser and shaving of the vitreous gel easier. The smaller gauges have not been without frustrations: instrumentation was originally clumsy, and many surgeons encountered quite a learning curve going from 20-gauge to smaller gauge procedures. As with any new technology, limitations in instrumentation and refinement of surgical technique presented early challenges: instrumentation flexibility, poor illumination and slow rate of vitreous removal and complications (such as hypotony, wound leak, choroidal detachment, retinal breaks). The most troubling complications noted in early outcome reports were the increased rates of endophthalmitis and iatrogenic breaks following small-gauge surgery.[11–13,27–37]

The lower rigidity of instruments was a problem with 25-gauge. These instruments were more pliable and more damageable, and therefore manipulation of the globe became cumbersome. The first version of 25-gauge instrumentation did not perform well: the forceps were difficult to control, and the surgical procedure was time-consuming for both vitrectomy and the removal of silicon oil. However, because of its similarity to 20-gauge in terms of rigidity, lighting, flow and aspiration of the vitreous cutter, 23-gauge became an easier switch with a smaller learning curve.

23-gauge Vitrectomy and Diffusion to Macular Surgery and Retinal Detachment Surgery (2005–2009)

The 23-gauge vitrectomy provided surgeons with a common surgical system to perform almost all kinds of vitreoretinal surgery with several advantages: economic, procedure standardisation, easier learning curve and fellow's training. Therefore, many different centres have started to use 23-gauge techniques since 2005.[13–15,38–40] Patients underwent single-step three-port 23-gauge dye-assisted (triamcinolone acetonide to identify the hyaloid and infracyanine green to identify the internal limiting membrane [ILM]) core vitrectomy using Accurus® (Alcon, Alcon Laboratories Inc. [a Novartis Company], Fort Worth, Texas, US) or D.O.R.C® Vitrectomy Platforms (Kerkweg, The Netherlands).

The incidence of endophthalmitis has been shown not to increase after the transition to 23-gauge surgery.[13,38–40] However, in a retrospective cohort study in our centre[41] we identified an increased rate of endophthalmitis (1 %) compared with the standard 20-gauge sutured counterpart performed in the same hospital. The surgical records of patients with clinically diagnosed endophthalmitis were reviewed. Of note, the vitreous tap revealed the presence of *Staphylococcus* coagulase-negative; a germ that was innocuous until 4 years ago in our area (North-west of Italy) and now shows multiple resistance to the antibiotics. Conversely, in 20 years of experience with the 20-gauge vitrectomy in the Torino Eye Trauma Center (n=3,500 cases), only one case of postoperative endophthalmitis occurred in a patient with diabetes with low Karnofsky index.

The incidence of retinal detachment after macular surgery has been shown not to increase in small-gauge, sutureless vitrectomy compared with the standard 20-gauge procedure.[42] However, an increased rate of retinal detachment in macular surgery managed by 23-gauge core-vitrectomy was also found.[43] In a clinical prospective study in our centre, postoperative retinal detachment occurred in two of the 166 consecutive eyes (median age 70, 95 male, 71 female) after 23-gauge MIVS surgery (1.2 %) in idiopathic epiretinal membrane surgery from October 2005 to May 2009.[43] The pathogenesis of retinal detachment in our surgical series could be correlated to the type of vitrectomy and induction of iatrogenic breaks. In the core vitrectomy technique residual vitreous in the periphery may cause retinal tractions and we recommend a scrupulous search for peripheral retinal breaks at the end of procedure: surgeons should be alert to the development of retinal breaks.

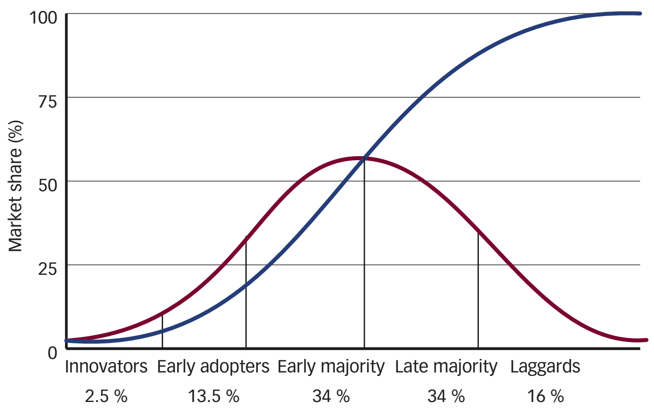
25-gauge Vitrectomy Coupled with New High-speed Vitrectomy Platforms (2009 to Present)

With the recent introduction of the next generation of ultra-high-speed 25-gauge vitrectomy system with duty cycle the field is moving towards a real revolution for the following reasons:

1. a smaller probe with the cutting port closer to the distal end of the tip gives access to tighter tissue plane during an epiretinal membrane dissection (i.e. diabetic retinopathy);
2. 25-gauge vitrectomy probe is stiff enough for peripheral vitreous shaving;
3. increased wound stability with new trocar blade design;
4. ultra-high-speed 25-gauge system with duty cycle control (7500 cpm) allows reduced retinal traction. High cut rates produce small vitreous bites that behave more like a low viscosity fluid. (less risk of iatrogenic breaks). The control of duty cycles allow individualised surgical approaches;
5. turbulence is also reduced at high cut speed, because smaller bites of vitreous results in smaller change in volume per time period with greater stability; and
6. bimanual surgery is performed less because the 25-gauge vitrectomy probe may be used as forceps, scissor or delamination spatula when necessary without exit from the eye.

A wide array of vitreoretinal microsurgical instruments have now been designed. These include vitreous cutters, trocars, illumination probes, intraocular forceps, microvitreoretinal blades,

Figure 1: The Adoption of a New Surgical Technique



Innovators: technology enthusiasts
Early adopters: visionaries
Early majority: pragmatists
Late majority: conservatives
Laggards: sceptics

tissue manipulators, aspirating picks, aspirators, soft-tip cannulas, curved scissors, extendable curved picks, extendable curved intraocular laser probes and diathermy probes.

The bimanual approach is becoming less common with the improvements in surgical techniques. Better visualisation with wide-angle systems, small calibre instrumentation and high cut-ratio probes allow most of the tractions to be solved without direct manipulation of the retina with two forceps. When a bimanual approach is necessary, the new 25 to 27-gauge chandeliers usually provide an optimal amount of light despite the smaller calibre. In these situations, Eckardt and crocodile forceps can delaminate any membrane without the need of scissors.

What Next?

Transitioning to advanced surgical technology is a complex matter for the surgeon, the hospital team and the hospital administration. In the early days of sutureless, small-incision vitreous surgery, surgeons were hampered by limited options for illumination and other instrumentation and a steep learning curve.

Adoption of a new technique is an individual process detailing the series of stages one undergoes from first hearing about a product to finally adopting it. The diffusion process, however, signifies a group of phenomena, which suggests how an innovation spreads among consumers. Overall, the diffusion process essentially encompasses the adoption process of several individuals over time. Within the rate of adoption, there is a point at which an innovation reaches critical mass. This is a point in time within the adoption curve that the number of individual adopters ensures that continued adoption of the innovation is self-sustaining (see *Figure 1*). Roger's work asserts that four main elements influence the spread of a new idea: the innovation, communication channels, time, and social system.[44] These elements work in conjunction with one another: diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Rogers adds that central to this theory is process. Individuals experience five stages of accepting a new innovation: knowledge, persuasion, decision, implementation and confirmation. If the innovation is adopted, it spreads via various communication channels. However we need to sharpen the focus with respect to gaining hard outcomes and not succumbing to the fashions of new developments. This approach of evaluating new technologies is fundamental prior to adopting.

Several companies have started to develop instruments to work with the smaller systems. These now include the 23/25G Stellaris® PC Vision Enhancement System (Bausch & Lomb, Bridewater, NJ, US), 23/25/27G Accurus and CONSTELLATION® Vision Systems (Alcon, Fort Worth, Texas, US), D.O.R.C's 23/25/27G systems (Exeter, NH) and Synergetics™ 23/25/27G, systems (O'Fallon, MO) and vitrectomy cutters produced by MiD Labs™ (San Leandro, CA).

Small-gauge Vitrectomy

Since the introduction of small-gauge vitrectomy[25,26] several modifications in technologies and techniques have allowed a continuous improvement in safety and efficiency of vitreoretinal procedures. Technological improvement of spring return pneumatic systems and the introduction of dual pneumatic drives have allowed the increase of cut rates up to 7,500 cpm with 125 cycles per second of opening and closing of the blade in 4 milliseconds without loss of efficiency at high frequencies with the possibility of controlling the duty cycle. The reduction of vitreous viscosity coupled with a minimal increase in aspiration levels has allowed the further reduction of the dimension of the probes to 27-gauge. The flow rate of the instruments is often a major concern but this must be looked at thoroughly in order to evaluate its real role: 25-gauge systems operating at 7,500 cpm with 650vac can guarantee a flow rate of 1.5 cc per minute corresponding to three times the level we have worked with previous generation 25-gauge vitrectors.[45–49]

Innovations in instruments and techniques have improved several fundamental aspects: four port vitrectomy with chandelier in conjunction with wide angle viewing systems and dyes allow a control of posterior and peripheral shaving and membrane removal that makes actual surgery difficult to compare with 5 years ago. Valved cannulas can guarantee a closed system with a better control of pressure changes and stiffer instruments allow a comfortable access to the retinal periphery. All these changes have modified our approach to difficult cases and vitrectomy is outperforming episcleral surgery not only in pseudophakic but also in phakic retinal detachment, with a limitation of long-acting tamponades in selected cases.

Looking at the past, several editorials have observed differences in the timing of adoption of smaller systems related to surgeon preferences or costs, although the trend is continuously moving towards less-invasive techniques. In less than 15 years the size of our probes has more than halved but the process of miniaturisation has probably not reached an endpoint, even though several problems will have to be overcome. Flow rate through small pipes is a main problem and the reduction of size to 27-gauge has imposed a significant reduction of vitreous flow to 0.43 cc/minute. Several ideas have already indicated possible solutions such as double port cutters, new drives with faster blades for further reduction of vitreous viscosity or entirely new methods of viscosity reduction with an enzymatical or electrochemical approach (Stanislao Rizzo, Italy, personal communication). The fact that we still do not have a true self-sealing surgery, as well as the possibility of new future therapeutical indications like submacular treatments or intravitreal implants, represent reasonably good motivations for further progression in this exciting path towards smaller vitrectomy systems.

Today, it is easy to find a wide range of vitreous cutters, chandeliers, curved scissors, microvitreoretinal blades, aspirating picks and endoscopic laser probes for both 23- and 25-gauge. This, in turn, has made it possible to expand the indications for these procedures. The 27-gauge vitrectomy (not yet available in the US) was first introduced in Japan, where it is being used on a limited basis for procedures such as macular surgery or floaters.[50] The 27-gauge technique also has the potential to be used for retinal detachment but the procedure is more time-consuming. Sclerotomies are safe, the learning curve is quick when a surgeon switches from 25-gauge surgical experience: the feeling is that the 27-gauge vitrectomy probes are stiff enough and similar to the 25-gauge ones.

However, a major misconception in the vitreoretinal community is that even smaller gauges may allow better performances. We should bear in mind the hard outcomes in a patient-oriented research: the rate of complications, and the long term effects in visual rehabilitation. The crucial question is 'Does the gauge really matter or is the technological innovation in the vitrectomy platform the challenge for the future?' As we said before, the revolution is not in an even smaller gauge but in the vitrectomy platforms. In 2002, the small 25-gauge calibre coupled to the old vitrectomy systems did not represent a real advancement: it could take 4 or 5 hours to fix a retinal detachment. The technological improvement in the vitrectomy systems since 2009 has allowed high cutting capability, better control of duty cycles with surgical times similar to the 20-gauge vitrectomy.

Surgeons need to transit to new vitreoretinal techniques: the rationale is to use a less-invasive technique with same results compared with more invasive techniques when we look to hard outcomes. Similar considerations were devoted to the transition from small incision cataract surgery (SICS) to minimally invasive cataract surgery (MICS).

In a limited-resource environment such as national health systems, it is critical to assess the value of healthcare programmes in terms of both their costs and outcomes and improvements in length and quality of life using economic evaluation methods. Health Technology Assessment (HTA) analyses can be used as inputs for cost-effectiveness studies to assist resource allocation decisions and not succumbing to the fashions of new developments. We reported the results of a first comparative analysis between 23- and 25-gauge vitrectomies in the management of macular epiretinal membranes, lamellar macular holes and myopic vitreomacular traction.[51] We performed HTA through analysis of effectiveness, safety and costs. Our results showed that 23- and 25-gauge techniques are equally effective in relieving vitreomacular adhesion, in resolving macular oedema and also in improving visual acuity. In the multivariate analysis the visual outcome was not correlated with the type of surgical technique (23- versus 25-gauge), or with the experience of the surgeon. These data are confirmed in recent publications where the visual prognosis depends on the integrity of the external limiting membrane and on the health of the photoreceptors.[52,53] Ophthalmologists should be aware that good selection of candidates is crucial for this type of surgery; we stress the importance of the time to surgery because chronic macular oedema has less functional results. The cut-off in visual acuity to decide on surgical peeling of the epiretinal membrane has therefore changed in the last few years; our study mirrors the old criteria (visual acuity of 6/18 or less) included in the 2010 guidelines at our Department of Ophthalmology. We now propose this type of surgery when visual acuity deteriorates in a 6-month interval, independently of a specific visual acuity threshold, and/or when patients complain of distortions in their reading activity.

Table 1: Comparison Costs Between 23- and 25-gauge (Euros)

	23-gauge	25-gauge	p value
Total surgical costs	1217.70±205.09	1164.84±178.51	0.351
Staff	199.05±72.23	171.92±62.18	0.194
Materials	788.60±84.35	753.04±35.32	0.0002*
Operating room	291.36±105.71	251.65±91.01	0.194
Epiretinal membranes	358.16±156.58	316.15±142.34	0.381
Staff	145.37±63.55	128.32±57.78	0.381
Operating room	212.79±93.03	187.83±84.57	0.381

**Mann Whitney test.*

Table 2: Comparison Costs Between Vitrectomy and Surgery Associated with Cataract (Euros)

	Vitrectomy	Vitrectomy Combined with Cataract	p value
Total surgical costs	1123.00±208.51	1209.32±171.18	0.12
Staff	164.52±75.72	186.35±60.64	0.29
Materials	765.35±85.73	763.31±37.08	0.0000*
Operating room	240.82±110.84	272.78±88.77	0.29
Epiretinal membranes costs	350.21±170.67	317.22±134.72	0.47
Staff	142.14±69.27	128.75±54.68	0.47
Operating room	208.06± 01.40	188.46±80.04	0.47

**Mann Whitney test.*

Cost analysis showed that the 25-gauge vitrectomy was slightly cheaper than the 23-gauge, as the surgical time was longer in the 23-gauge group and the materials more expensive. The differences in the costs of materials between 23- and 25-gauge were correlated with the type of technique (23-versus 25-gauge) but not to the surgery type (vitreoretinal surgery alone or combined with cataract surgery (see *Tables 1* and *2*).

The transition to new vitrectomy platforms needs to be validated in three significant measures of surgical efficiency: operative number of patients per day, operative room time and surgical procedure time that reflect the positive impact of the novel, combined, integrated functions. The major concerns remain the safety of the procedures and the long-term success rate.

Special Clinical Focus

State of Art in Macular Surgery

The technique for surgical macular pathology (epiretinal membrane, vitreoretinal interface disorders, macular holes) has benefited from tremendous advancements in imaging technologies (spectral domain optical coherence tomography [SD OCT]) and intraoperative dyes.

For macular epiretinal membrane, there is agreement to perform a core vitrectomy dye assisted with double peeling of hyaloid and ILM: triamcinolone is used to stain the hyaloid and a blue dye – MembraneBlue™ (D.O.R.C, Kerkweg, the Netherlands) or Brilliant Blue (D.O.R.C, Kerkweg, Netherlands) to stain ILM. However, some surgeons propose to perform a peripheral vitrectomy + endolaser to minimise the risk of residual vitreal traction (Grazia Pertile, Negrar, Italy, personal communication). Nowadays, ILM peeling is performed by many surgeons to promote macular hole closure and to reduce the rate of epiretinal membranes recurrence.[54] For macular holes there is agreement to perform a vitrectomy as complete as possible along with double peeling of hyaloid and ILM and gas tamponade. In our experience in Torino we use 0.2 ml of C_3F_8 at the end of the procedure. In Spain, short-acting gases, especially SF_6, are more often used as tamponade agents in macular hole surgery. The majority of studies suggest an overall beneficial effect of posturing in terms of closure of holes; however, there is heterogeneity regarding duration of face-down positioning. The evidence for the impact of postoperative face-down positioning on the outcome of surgery for macular holes is not conclusive.

Combined procedures consisting of MIVS and phacoemulsification with IOL implantation are gaining popularity to avoid a second operation to the patient. A phacovitrectomy is mainly indicated in the presence of lens opacity and in patients over 60 years. Cataract surgery is usually performed by the same vitreoretinal surgeon. The long-term functional results are correlated to the integrity of external limiting membrane and retinal microstructure.[55–58]

The management of vitreoretinal interface is more complex, depending on the pathogenesis and may take advantage from enzymatic vitreolysis: better understanding of the interactions between vitreous gel and retinal surface are still needed. The onset and progression of macular epiretinal membranes and macular holes vary according to different pathological mechanisms. Microglia play a pivotal role: glial cells may change their phenotype to antigen presenting cells (APC) under the stimulation of inflammatory chemokines and are able to induce a immune-mediated waterfall of events that lead to pathological, non-reversible, changes.[59–65]

Despite the improvements in safety with the new surgical techniques, rhegmatogenous retinal detachment secondary to iatrogenic peripheral retinal breaks remain a serious postoperative complication, which requires additional surgery. Shave vitrectomy under air adjunct to standard core vitrectomy has been shown to be a safe technique. In the experience of the Ophthalmology Department, Polytechnic University of Marche, Ancona a lower incidence of retinal breaks was found in vitrectomy under air than in standard vitrectomy (Cesare Mariotti, personal communication). Favourable results of the airbag vitrectomy may be related to two main advantages offered by the air: better intraoperative visualisation, as under air the visual field is wider; safer removal of the vitreous base, as the air helps stabilising the retina.

State of Art in Retinal Detachment Surgery – Old Debate in the New Era – Buckle or Not?

It is difficult to answer yes or no, as it really depends on the case.[66] The general impression is that we do increasingly less scleral buckle surgery, probably for the following reasons:

1. young ophthalmologists are not trained in the use of indirect ophthalmoscope; and
2. with the 25-gauge 'Windows revolution' a lot of surgeons carry out macular surgery and are more confident with the vitreoretinal techniques rather than scleral buckle when they need to approach retinal detachment surgery (it is similar to developments in the cataract surgery field: young surgeons do not have experience with extracapsular surgery). We say 'Windows revolution' because vitreoretinal surgery is more popular and has opened up to more surgeons in comparison to the era of scleral buckle surgery, which was restricted to few surgeons.

What about choices and the trends in retinal detachment surgery? A common, easy way to classify the retinal detachments phenotypes is to follow the European Vitreo-retinal Society (EVRS) indications:[67] a) simple (50 %) with single tear or limited retinal detachment; b) medium complexity retinal detachment (30 % of cases, multiple retinal tears, large retinal tears, bullous detachments, proliferative vitreoretinopathy [PVR] up to B grade, undetected retinal tears); and c) complicated retinal detachments (20 % of cases, recurrent retinal detachment, PVR).

In our centre, for uncomplicated retinal detachments we use radial or circumferential segmental epiretinal implants or scleral buckle when vitreous gel is good, otherwise we convert to MIVS. It may be reasonable to use buckle without vitrectomy in young phakic patients with no posterior vitreous detachment (PVD). We use and recommend primary 25-gauge vitrectomy coupled with high-speed platforms as a first-line approach in medium complexity retinal detachments according to the Scleral buckling vs Primary vitrectomy in Rhegmatogenous retinal detachment Study.[68,69] However, randomised controlled trials (RCTs) and large-scale non-randomised observational studies are needed to determine with confidence the value of new high-speed 25-gauge vitrectomy. In case of a fresh, macula on, retinal detachment the timing for surgery is on the same day of presentation.[68]

In complicated cases of retinal detachment all surgeons perform vitrectomy:[70] the evidence for the impact of combined PPV and scleral buckle on the outcome of surgery for retinal detachment in complex cases according to the EVRS study[71–73] or in myopic eyes is not conclusive. Retinal detachment recurrences and PVR grade b and c cases are still grey zones. The different approaches also mirror different epidemiological contexts and organisational (public and private practice) settings; for example, in Singapore, vitrectomy is most often combined with scleral buckling for the retinal detachment including those with single tear, phakic eyes, PVR. (Boon Kwang, Singapore National Eye Centre and Singapore Eye Research Institute, January 2013, personal communication).

Given that there is a wide spectrum of options for treatment of retinal detachment, the surgeons' experience with the chosen surgical technique will be of utmost importance in obtaining the best surgical result. As guidelines, they are intended as an additional aid to the surgeon during the decision-making process, with the expectation that the final choice will still be left to the surgeon's judgement and past experience.[66]

A vitrectomy allows to traction exerted by the vitreous on the retina to be relieved, internal drainage of subretinal fluid and laser around retinal tears. In Spain, SF_6 gas is widely used as tamponade agents. In Italy, and in our centre, there is more experience with C_3F_8. Silicone oil tamponade is mainly used in retinal detachment cases complicated by PVR.

When it is indicated to perform a vitrectomy in Torino, all cases are performed with 25-gauge vitrectomy except for giant retinal tears and in high myopia. We do not combine scleral buckle with PPV in the management of retinal detachment, especially in high myopia, when we are concerned to increase the anteroposterior length. Primary vitrectomy has been demonstrated as equally effective to combined PPV and scleral buckle in terms of anatomical and functional recovery.[71–73] This change in paradigm is the current revolution in the field of vitreoretinal surgery in the approach to medium complexity and complicated cases. However, we lack data on long-term functional and anatomical outcomes. Further, we are required to wait for the conclusions of RCTs and prospective clinical studies to evaluate the effectiveness of new high-speed 25-gauge vitrectomy compared with the combined procedure (high-speed 25-gauge vitrectomy + scleral buckle) in the management of retinal detachment surgery. We are confident with these parameters when we use the 25-gauge parameters coupled with the CONSTELLATION platform: cutting speed of 5,000 cuts per minute, infusion pressure of 35 mmHg and aspiration pressure of 650 mmHg. We recently had the opportunity to use the Enhanced Visual Acuity (EVA®) System by D.O.R.C (Kertweg, the Netherlands). We perform a full vitrectomy with BIOM® system (Oculus, Wetzlar, Germany) or RESIGHT 500 Fundus Viewing System (Carl Zeiss Meditec, Dublin, California, US).

The main difference when we compare preferred practice patterns between Spain and Italy is that in Spain a combined procedure consisting of vitrectomy and encircling band is performed by many surgeons in cases of recurrences, PVR and in young patients. In Italy, the trend is towards primary vitrectomy as the technique of choice in the management of recurrent retinal detachment.

In terms of the debate 'small gauge, better results' it really depends on the surgeon's experience, learning curve and the availability of high-tech, expensive vitrectomy platforms (such as CONSTELLATION, EVA and Stellaris). For example, in Italy some regions close to Austria and Switzerland use 23-gauge more commonly than 25-gauge for geo-political reasons (the D.O.R.C and Hoertli headquarters are close to Italy).

Overall, the use of buckles are decreasing worldwide and we believe that one day we will find the characteristics of the retinal detachments where vitrectomy alone will be as safe as, for example combined vitrectomy and scleral buckle, or we will be able to ensure we find all the breaks with perfect view of the posterior border of vitreous base, and perhaps other type of vitreous cutting, safer than the mechanical type (guillottine-like) we use now will be available.

In conclusion, surgical management of primary retinal detachment has changed greatly in 20 years. However, success rates have changed little, despite availability of differing surgical techniques.[74]

Conclusion

In the era of the 'Windows revolution' small-gauge surgery has been opened up to an increased number of surgeons; however, we believe that our surgical art should not be democratised. On the contrary, we believe that it is of public interest, to make it 'aristocratic', that is, to improve the quality of its practitioners. It is mandatory that the surgeon, because of his or her difficult mission, should have complete scientific and moral independence.[75] The human component is of fundamental importance because surgical strategy gains diffusion depending on the surgeon's personality and wisdom.[44–76] In any event, the best technique is the one that works best in each practitioner's hands.

We should always bear in mind the 'neminem laedere' principle: in surgery, the rationale is to use the least invasive technique with the same anatomical and functional results. 'When in doubt, don't.' ■

1. Klein BE, Howard KP, Lee KE, Klein R. Changing Incidence of Lens Extraction over 20 Years: The Beaver Dam Eye Study, *Ophthalmology*, 2014;121:5–9.
2. Erie JC Rising cataract surgery rates: demand and supply, *Ophthalmology*, 2014;121:2–4.
3. Finger RP, Kortuem K, Fenwick E, von Livonius B, Keeffe JE, Hirneiss CW, Evaluation of a vision-related utility instrument: the German vision and quality of life index, *Invest Ophthalmol Vis Sci*, 2013;1;54:1289–94.
4. Taylor HR, Hien TV, Keefe JE. Visual acuity thresholds for cataract surgery and changing Australian population, *Arch Ophthalmol*, 2006;124:1750–3.
5. Benedetti F, The Patient's Brain, The neuroscience behind the doctor-patient relationship, Oxford, UK: Oxford University Press, 2011.
6. Ackerman MJ, Personalized medicine, *J Med Pract Manage*, 2009;25:194–5.
7. Arevalo JF, Berrocal MH, Arias JD, Banaee T, Minimally invasive vitreoretinal surgery: is sutureless vitrectomy the future of vitreoretinal surgery? *J Ophthalmic Vis Res*, 2011;6:136–44.
8. Williams GA. 25-, 23-, or 20-gauge instrumentation for vitreous surgery?, *Eye (Lond)*, 2008;22:1263–6.
9. Fabian ID, Moisseiev J, Sutureless vitrectomy: evolution and current practices, *Br J Ophthalmol*, 2011;95:318–24.
10. Hubschman JP, Gupta A, Bourla DH, et al., 20-, 23-, and 25-gauge vitreous cutters: performance and characteristics evaluation, *Retina*, 2008;28:249.
11. Inoue Y, Kadonosono K, Yamakawa T, et al., Surgically induced inflammation with 20-, 23-, and 25-gauge vitrectomy systems: an experimental study, *Retina*, 2009;29:477–80.
12. Scott IU, Flynn HW, Jr, Acar N, et al., Incidence of endophthalmitis after 20-gauge vs 23-gauge vs 25-gauge pars plana vitrectomy, *Graefes Arch Clin Exp Ophthalmol*, 2011;249:377–80.
13. Parolini B, Prigione G, Romanelli F, et al., Postoperative complications and intraocular pressure in 943 consecutive cases of 23-gauge transconjunctival pars plana vitrectomy with 1-year follow-up, *Retina*, 2010;30:107.
14. Grosso A, Panico C, Tips and pitfalls in 23-gauge vitrectomy surgery: does one size fits (almost) all?, *Graefes Arch Clin Exp Ophthalmol*, 2009;247:1711–2.
15. Parolini B, Romanelli F, Prigione G, Pertile G, Response to Letter: Tips and pitfalls in 23-gauge vitrectomy surgery: does one size fits (almost) all? Comment on the article "Incidence of endophthalmitis in a large series of 23-gauge and 20-gauge transconjunctival pars plana vitrectomy", *Graefes Arch Clin Exp Ophthalmol*, 2009;247:1713–4.
16. Savastano A, Savastano MC, Barca F, et al., Combining cataract surgery with 25-gauge high-speed pars plana vitrectomy: results from a retrospective study, *Ophthalmology*, 2014;121:299–304.
17. Yiu G, Marra KV, Wagley S, et al., Surgical outcomes after epiretinal membrane peeling combined with cataract surgery, *Br J Ophthalmol*, 2013;97:1197–20.
18. Berrod JP, Hubert I, Combined phacoemulsification and pars plana vitrectomy, *J Fr Ophtalmol*, 2012;35:561–5
19. Taylor HR, LXIII Edward Jackson Memorial Lecture: Eye care: dollars and sense, *Am J Ophthalmol*, 2007;143:1–8.
20. Taylor HR, Boudville AI, Anjou MD, The roadmap to close the gap for vision, *Med J Aust*, 2012;10:613–5.
21. Roberts CB, Hiratsuka Y, Yamada M, et al., Economic cost of visual impairment in Japan, *Arch Ophthalmol*, 2010;128:766–7
22. World Health Organization. Global Initiative for Elimination of Avoidable Blindness. Geneva, Switzerland: World Health Organization; 2000;WHO/PBL/97.61 Rev 2. Available at: whqlibdoc.who.int/hq/1997/WHO_PBL_97.65.pdf (last accessed 30 June 2014).
23. Karlgaard R, Gilder's Triumph. Knowledge and Power, *Forbes*, 15 July 2013;30.
24. Benedetti F, Placebo and the new physiology of the doctor-patient relationship, *Physiol Rev*, 2013;93:1207–46.
25. Fujii GY, De Juan E, Jr, Humayun MS, et al., A new 25-gauge instrument system for transconjunctival sutureless vitrectomy surgery, *Ophthalmology*, 2002;109:1807–12.
26. Fujii GY, De Juan E, Jr, Humayun MS, et al., Initial experience using the transconjunctival sutureless vitrectomy system for vitreoretinal surgery, *Ophthalmology*, 2002;109:1814–20.
27. Eckardt C, Transconjunctival sutureless 23-gauge vitrectomy, *Retina*, 2005;25:208–11.
28. Ibarra MS, Hermel M, Prenner JL, Hassan TS, Longer-term outcomes of transconjunctival sutureless 25-gauge vitrectomy, *Am J Ophthalmol*, 2005;139:831–6.
29. Lakhanpal RR, Humayun MS, de Juan E Jr, et al., Outcomes of 140 consecutive cases of 25-gauge transconjunctival surgery for posterior segment disease, *Ophthalmology*, 2005;112:817–24.
30. Kellner L, Wimpissinger B, Stolba U, et al., 25-gauge vs 20-gauge system for pars plana vitrectomy: a prospective randomised clinical trial, *Br J Ophthalmol*, 2007;91:945–8.
31. Wimpissinger B, Kellner L, Brannath W, et al., 23-Gauge versus 20-gauge system for pars plana vitrectomy: a prospective randomised clinical trial, *Br J Ophthalmol*, 2008;92:1483–7.
32. Inoue M, Noda K, Ishida S, et al., Intraoperative breakage of a 25-gauge vitreous cutter, *Am J Ophthalmol*, 2004;138:867–9.
33. Taylor SR, Aylward GW, Endophthalmitis following 25-gauge vitrectomy, *Eye (Lond)*, 2005;19:1228–9.
34. Kunimoto DY, Kaiser RS, Incidence of endophthalmitis after 20- and 25 gauge vitrectomy, *Ophthalmology*, 2007;114:2133–7.
35. Liu DT, Chan CK, Fan DS, et al., Choroidal folds after 25 gauge transconjunctival sutureless vitrectomy, *Eye (Lond)*, 2005;19:825–7.
36. Okuda T, Nishimura A, Kobayashi A, Sugiyama K, Postoperative retinal break after 25-gauge transconjunctival sutureless vitrectomy: report of four cases, *Graefes Arch Clin Exp Ophthalmol*, 2007;245:155–7.
37. Gupta OP, Weichel ED, Regillo CD, et al., Postoperative complications associated with 25-gauge pars plana vitrectomy, *Ophthalmic Surg Lasers Imaging*, 2007;38:270–5.
38. Fine HF, Iranmanesh R, Iturralde D, Spaide RF, Outcomes of 77 consecutive cases of 23-gauge transconjunctival vitrectomy surgery for posterior segment disease, *Ophthalmology*, 2007;114:1197–200.
39. Tewari A, Shah GK, Fang A, Visual outcomes with 23-gauge transconjunctival sutureless vitrectomy, *Retina*, 2008;28:258–62.
40. Schweitzer C, Delyfer MN, Colin J, Korobelnik JF, 23-Gauge transconjunctival sutureless pars plana vitrectomy: results of a prospective study, *Eye (Lond),* 2009;23:2206–14.
41. Grosso A, Panico C, A critical debate about the prophylaxis strategies in patients who undergo intravitreal injections is warranted, *Retina*, 2008;28:1556–7.
42. Rizzo S, Belting C, Genovesi-Ebert F, di Bartolo E, Incidence of retinal detachment after small-incision, sutureless pars plana vitrectomy compared with conventional 20-gauge vitrectomy in macular hole and epiretinal membrane surgery, *Retina*, 2010;30:1065–71.
43. Grosso A, Panico C, Incidence of retinal detachment following 23-gauge vitrectomy in idiopathic epiretinal membrane surgery, *Acta Ophthalmol*, 2011;89:e98
44. Rogers E, 2003: The Diffusion of Innovations. Fifth Edition. New York: The Free Press, FGB, 4437;4.
45. Abulon DJK, Buboltz DC, Porcine vitreous flow behavior during high speed vitrectomy up to 7500 cuts per minute, *Invest Ophthalmol Vis Sci*, 2012;53:ARVO E-Abstract 36915.
46. Ray A, Dina JK, Abulon DJK, Buboltz DC, Poster, intraocular pressure and BSS flow rates at high vitrectomy probe cut rates – ARVO 2012 Program Number: 3759 Poster Board Number: A225. Fort Lauderdale, US.
47. Rizzo S, Performance of a modified vitrectomy probe in small gauge vitrectomy:an experimental and clinical study. Paper presented at American Society of Retina Specialists annual meeting 2011; Boston, US.
48. Dugel PU, Zhou J, Abulon DJ, Buboltz DC, Tissue attraction associated with 20-gauge, 23-gauge, and enhanced 25-gauge dual-pneumatic vitrectomy probes, *Retina*, 2012;32:1761–6.
49. Barnes AC, DeBoer CM, Bhadri PR, et al., Humayun 25-gauge instrumentation: engineering challenges and tradeoffs. In: Rizzo S, Patelli F, Chow D, eds, *Vitreo-retinal surgery progress III*, Heidelberg, Germany: Springer, 2009.
50. Oshima Y, Wakabayashi T, Sato T, et al., A 27-gauge instrument system for transconjunctival sutureless microincision vitrectomy surgery, *Ophthalmology*, 2010;117:93–102.
51. Grosso A, Charrier L, Lovato E, et al., Twenty-five-gauge vitrectomy versus 23-gauge vitrectomy in the management of macular diseases: a comparative analysis through a Health Technology Assessment model, *Int Ophthalmol*, 2014;34:217–23.
52. Cobos E, Arias L, Ruiz-Moreno J, et al., Preoperative study of the inner segment/outer segment junction of photoreceptors by spectral-domain optical coherence tomography as a prognostic factor in patients with epiretinal membranes, *Clin Ophthalmol*, 2013;7:1467–7.
53. Ruiz-Moreno JM, Arias L, Araiz J, et al., Spectral-domain optical coherence tomography study of macular structure as prognostic and determining factor for macular hole surgery outcome, *Retina*, 2013;33:1117–22.
54. Haritoglou C, Reiniger IW, Schaumberger M, et al., A five-year follow-up of macular hole surgery with peeling of the internal limiting membrane: update of a prospective study, *Retina*, 2006;26:618–22.
55. Figueroa MS, Contreras I, Noval S, Surgical and anatomical outcomes of pars plana vitrectomy for diffuse nontractional diabetic macular edema, *Retina*, 2008;28:420–6.

56. Spiteri Cornish K, Lois N, Scott NW, et al., Vitrectomy with internal limiting membrane peeling versus no peeling for idiopathic full-thickness macular hole, *Cochrane Database Syst Rev*, 2013;6:CD009306
57. Barth T, Zeman F, Helbig H, Gamulescu A, Value of preoperative optical coherence tomography for predicting visual outcome after epiretinal membrane surgery, *Int Ophthalmol*, 2014;34:773–9.
58. Shiono A, Kogo J, Klose G, et al., Photoreceptor outer segment length: a prognostic factor for idiopathic epiretinal membrane surgery, *Ophthalmology*, 2013;120:788–94.
59. Ma W, Coon S, Zhao L, et al., A2E accumulation influences retinal microglial activation and complement regulation, *Neurobiol Aging*, 2013;34:943–60.
60. Murinello S, Mullins RF, Lotery A, et al., Fcγ receptor upregulation is associated with immune-complex inflammation in the mouse retina and early age-related macular degeneration, *Invest Ophthalmol Vis Sci*, 2014;55:247–58.
61. Stalmans P, Benz MS, Gandorfer A, et al.; MIVI-TRUST Study Group. Enzymatic vitreolysis with ocriplasmin for vitreomacular traction and macular holes, *N Engl J Med*, 2012;16:606–15.
62. Sebag J, Molecular biology of pharmacologic vitreolysis, *Trans Am Ophthalmol Soc*, 2005;103:473–94.
63. Duker JS, Moshfeghi AA, Ocriplasmin: a medical or surgical therapy?, *Retina*, 2013;33:2001.
64. Singh RP, Li A, Bedi R, et al., Anatomical and visual outcomes following ocriplasmin treatment for symptomatic vitreomacular traction syndrome, *Br J Ophthalmol*, 2014;98:356–60.
65. Stalmans P, Girach A, Vitreous levels of active ocriplasmin following intravitreal injection: results of an ascending exposure trial, *Invest Ophthalmol Vis Sci*, 2013;9:6620–7.
66. García-Arumí J, Martínez-Castillo V, Boixadera A, et al., Rhegmatogenous retinal detachment treatment guidelines, *Arch Soc Esp Oftalmol*, 2013;88:11–3.
67. Adelman RA, Parnes AJ, Ducournau D; European Vitreo-Retinal Society (EVRS) Retinal Detachment Study Group. Strategy for the management of uncomplicated retinal detachments: the European vitreo-retinal society retinal detachment study report 1, *Ophthalmology*, 2013;120:1804–8.
68. Schwartz SG, Flynn HW Jr, Mieler WF, Update on retinal detachment surgery, *Curr Opin Ophthalmol*, 2013;24:255–61.
69. Heimann H, Bartz-Schmidt KU, Bornfeld N, et al., Scleral Buckling versus Primary Vitrectomy in Rhegmatogenous Retinal Detachment Study Group. Scleral buckling versus primary vitrectomy in rhegmatogenous retinal detachment: a prospective randomized multicenter clinical study, *Ophthalmology*, 2007;114:2142–54.
70. Adelman RA, Parnes AJ, Sipperley JO, Ducournau D, European Vitreo-Retinal Society (EVRS) Retinal Detachment Study Group. Strategy for the management of complex retinal detachments: the European vitreo-retinal society retinal detachment study report 2, *Ophthalmology*, 2013;120:1809–13.
71. Weichel ED, Martidis A, Fineman MS, et al., Pars plana vitrectomy versus combined pars plana vitrectomy-scleral buckle for primary repair of pseudophakic retinal detachment, *Ophthalmology*, 2006;113:2033–40.
72. Figueroa MS, Contreras I, Noval S, PACORES Study Group. Anatomic and visual outcomes of 23-G vitrectomy without scleral buckling for primary rhegmatogenous retinal detachment, *Eur J Ophthalmol*, 2013;23:417–22.
73. Romano MR, Das R, Groenwald C, et al., Primary 23-gauge sutureless vitrectomy for rhegmatogenous retinal detachment, *Indian J Ophthalmol*, 2012;60:29–33.
74. Soni C, Hainsworth DP, Almony A, Surgical management of rhegmatogenous retinal detachment: a meta-analysis of randomized controlled trials, *Ophthalmology*, 2013;120:1440–7.
75. Liberati A, Need to realign patient-oriented and commercial and academic research, *Lancet*, 2011;378(9805):1777–8.
76. Lanfranco AR, Castellanos AE, Desai JP, Meyers WC, Robotic surgery: a current perspective, *Ann Surg*, 2004;239:14–21.