



## SCHWIND AMARIS

*Clinical experience with the latest excimer laser generation*

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# Introduction

There have been many exciting developments in refractive surgery as doctors seek out the latest technology to improve outcomes and meet patients' expectations for better outcomes.

In this special roundtable, sponsored by SCHWIND, leading surgeons from around the world discuss some of these developments, focusing in particular on the SCHWIND AMARIS laser.

The moderator is Prof John Marshall, the Frost Professor of Ophthalmology and head of the Department of Ophthalmology,

Kings College London, University of London at St Thomas' Hospital. Prof Marshall is a pioneer and an internationally recognised expert on laser and light bio-effects in the field of ophthalmology. He is the co-inventor of the world's first diode laser for ophthalmology and the inventor of excimer laser technology for refractive surgery. Prof Marshall is joined at the roundtable by Prof Jorge Alió, Spain, Dr Maria-Clara Arbelaez, Oman, Dr Carmen Barraquer, Colombia, Dr Francesco Carones, Italy and Prof Detlef Uthoff, Germany.



John Marshall



Jorge Alió



Maria-Clara Arbelaez



Carmen Barraquer



Francesco Carones



Detlef Uthoff

## Background and introduction

**Prof Marshall:** I would like to welcome you all to this roundtable and I look forward to a lively debate. Today we will discuss your individual experiences with the SCHWIND AMARIS, the exciting new opportunities offered by the latest laser technology and the importance of clinical outcomes. We will also discuss customised solutions and eye tracking with the SCHWIND AMARIS before we conclude with a general discussion on the future of refractive surgery.

I should stress at this stage that I do not expect you to have an answer to every question, so feel free to ignore those questions which you feel are outside of your remit or experience.

I would like to open the discussion by asking you to tell me about your experiences in performing refractive surgery. I will begin by asking how patients' expectations have changed since you first began performing refractive surgery and how long have you been performing refractive surgery with the SCHWIND AMARIS?

**Prof Alió:** I have been performing surgery since 1991, when we got the first excimer laser 20/20 B (Visx) in Spain. Initially, patients were excited about the correction of myopia. Now they are concerned about the precision of the correction and the quality of vision.

Patients now understand that full correction can be achieved and that this may be virtually complication free. This is our commitment today.

**Dr Barraquer:** Since the beginning of my ophthalmological practice in 1977 we were performing the technique of clear lens extraction in high myopes, crescent resections in high mixed astigmatism and relaxing incisions in post PK astigmatism. I began to perform keratomileusis (freezing) in 1980, followed by radial and astigmatic keratotomies in low myopic and mixed astigmatism defects; epikeratophakia and epikeratoplasty in 1982, and since 1988, keratomileusis in situ with and without hinge, until we were able to obtain a first excimer laser in 1994. We have been performing refractive surgery with the SCHWIND AMARIS since July 2007.

In the beginning we were trying to reduce high refractive errors. Results between  $\pm 3.0$  dioptres were considered adequate. Nowadays, the patient does not accept or understand the least residual error. Not only have patients' expectations changed; the refractive surgeon's perfection level is an engine that encourages research and the improvement of hardware and software.

**Dr Carones:** I have been involved in refractive surgery since my residency (1988) and I started performing PRK in 1990. From there, I went through LASIK in 1995 and intraocular refractive surgery in 1996. Expectations have dramatically increased since my early refractive

surgery days. I remember when we used to perform PRK with 4.5mm or 5.0mm ablation diameters to correct even high corrections, regardless of the pupil size and, although with some difficulties, patients were happy.

Today patients are much more demanding; not only do they want to be free from spectacles, they also want an uncompromised quality of vision at all distances, in all light conditions.

I first used the AMARIS in June 2007, participating at a multicentre trial. In one month, I performed roughly 60 procedures at that time. Then, in November 2007, I got the laser I am using right now, and started using it as my primary excimer laser.

**Dr Arbelaez:** I first performed refractive surgery in 1992. My initial experience was that the patients' aim was to have some independence from glasses and contacts. Nowadays, they want to have total freedom from glasses and contacts with vision of 20/20 or better. They are very aware of quality of vision, very well informed about the laser refractive procedures, such as wavefront technology, and their expectations are really very high. I used one of the first AMARIS lasers by March 2007 (560 eyes done), I received the final product in November 2007.

**Prof Uthoff:** I have been performing refractive surgery since 1981. I started with radial keratotomy and astigmatic keratotomy. In 1991, I started with PRK and switched over to LASIK at the beginning of 1993. Our patients' expectations have changed tremendously, ever since I have started with refractive surgery. The reasons for this are the increasing public interest and the media, leading to a higher awareness in them. Since December 2007, I have been performing refractive surgery (LASIK) with the SCHWIND AMARIS laser.

## Laser technology

**Prof Marshall:** Let us now start the second part of our discussion by talking about laser technology. Let me begin by asking you what are your criteria for selecting a laser system for refractive surgery?

**Dr Carones:** Given that the most important issue for an excimer laser platform is the consistency and reliability of the provided refractive results, I would say that the most important criteria are:

- 1) Updated technology. We don't want to invest in systems which may soon become obsolete. In my opinion, it is particularly important that all technology is related to the alignment and tracking process of the ablation.
- 2) Flexibility, in terms of available options and software, like the ability to perform corneal wavefront and total wavefront custom ablations, aberration-free profiles, presbyopia correction, etc.
- 3) Safety, in terms of centration of the ablation and smoothness of the ablated stromal side.

**Prof Uthoff:** My criteria for selecting a laser system are that it must be safe, fast, easy to handle and designed for patient comfort. It is important for its accuracy to have a small spot and it should be reliable.

**Dr Arbelaez:** I would consider reliability, the option of a range of treatments and after-sales services to be the essential criteria in the selection of a refractive system for laser surgery.

**Dr Barraquer:** My principal criteria are software, hardware, maintenance and price.

**Prof Marshall: I think we are all agreed that we must consider safety and reliability when we select a laser system. What other laser systems in addition to the SCHWIND AMARIS do you have experience with?**

**Prof Alió:** I have direct experience with the 20/20 B (Visx), S2 (Visx), EC-5000 (Nidek), LaserScan LSX (LaserSight), 217 Z (Bausch & Lomb), Mel 70 (Meditec), Mel 80 (Carl Zeiss Meditec) and SCHWIND ESIRIS (SCHWIND eye-tech-solutions).

**Dr Barraquer:** My first experience was with 20/20 (Visx) and after that the Keratom II (SCHWIND eye-tech-solutions) and the SCHWIND ESIRIS.

**Prof Uthoff:** I have experience with the MEL 50 and MEL 60 (both Meditec), Keracor 116, Keracor 217 Z100 (Bausch & Lomb) and SCHWIND ESIRIS.

**Dr Carones:** Excluding those "pioneering lasers" like the Summit (Autonomous) and the 20/20 that I have used prior to the year 2000, I have recent experience with the Keracor 217 C (Bausch & Lomb), LADARVision 4000 and 6000 (Alcon), iRES (iVIS Technologies) and the SCHWIND ESIRIS.

**Dr Arbelaez:** I have experience with Keracor 116, Keracor 117 and Keracor 217 (all Bausch & Lomb), EC-5000 and SCHWIND ESIRIS.

**Prof Marshall: Why do you think that the SCHWIND AMARIS is better than the competitive lasers?**

**Dr Arbelaez:** I have found that the SCHWIND AMARIS is completely reliable in results and has all the possible solutions for laser refractive surgery, such as aberration-free, corneal and ocular wavefront.

It has a true 500 Hz speed and is the fastest eye tracker that integrates static and dynamic cyclotorsion control, the particle aspiration system that makes the laser fully independent from environmental conditions and airflow.



Something that is really a big advantage is the possibility of selection during the planning of wavefront treatments with the ORK-CAM software. This means that the software suggests the most relevant aberrations to be treated for each particular case and you can treat only what is relevant for the patient. The microscope is totally different and provides 14 degrees of stereopsis with an excellent illumination.

**Prof Alió:** The SCHWIND AMARIS is the best of all the lasers I have used, as it is faster and it seems to be more reliable in terms of centration and tracking. It is very effective in the final transition areas. It has a unique control on pupil size and very good ergonomics.

**Prof Uthoff:** In my opinion, the SCHWIND AMARIS has more laser power and its online pachymetry is faster. It also has more sophisticated eye tracking, corneal and ocular wavefront and particle aspiration in comparison to the other competitive lasers.



*"In my opinion, the SCHWIND AMARIS has more laser power and its online pachymetry is faster"*

Prof Detlef Uthoff

**Dr Carones:** It is difficult to say if one laser can be better than the others. I think the AMARIS really integrates the most updated technology at least from a laboratory and engineering point of view. Although this is supposed to bring better results, these still have to be confirmed. At this point, I can say that, given the very rapid turnover of this kind of technology, the AMARIS seems to be long-lasting.

**Dr Barraquer:** The SCHWIND AMARIS is reliable in the refractive results that you expect to obtain. It offers the dual fluence approach that reduces treatment time and the software gives the surgeon the possibility to face the patient with a good armamentarium. It also has very good maintenance and is comfortable for the patient and for the doctor.

**Prof Marshall:** That is an interesting summary of some of the strengths of this particular laser. From your clinical point of view, how fast should treatment be? Is the speed of the SCHWIND AMARIS fast enough?

**Dr Barraquer:** In our world, "enough" is never the right word. Actual speed limits the requirement for the patient's fixation and decreases exposure time.

**Dr Carones:** There are at least three aspects related to the speed of the procedure. The first aspect relates to the biology: The treatment should be fast enough to avoid changes in hydration of the corneal stroma. The second and the third aspects are related to patient comfort and surgeon/team efficiency. I believe that for fulfilling all of these aspects, a treatment should never take longer than 45 seconds (as regards the ablation, of course). In my experience, this time frame was never exceeded using the AMARIS, even for high hyperopic corrections when using large optical zone sizes, which are the most challenging treatments in terms of time to treatment.

**Prof Uthoff:** From a clinical point of view, it is important that the treatment should be very fast. In my view, the speed of the SCHWIND AMARIS laser is sufficient.

**Dr Arbelaez:** The SCHWIND AMARIS has a 500 Hz true repetition rate. Treatments are on average 12 seconds or less and the patient hardly realises that the treatment has been done. Clinically, it is very relevant. You expose tissues to surgery time, recovery time is faster and results are better.

**Prof Marshall:** Moving on to our next question, what is your opinion about the Intelligent Thermal Effect Control implemented at the SCHWIND AMARIS platform?

**Dr Carones:** The Intelligent Thermal Effect Control avoids local peaks in heating of the stroma, which is supposed to bring results that are more consistent and less stromal reaction when performing surface ablation. While comparative laboratory and clinical studies are still missing, I think that from a theoretical perspective, lower temperatures may really bring better clinical results.

**Dr Arbelaez:** I believe that is one of the keys in the laser to achieve such perfect results. There is a dynamic distribution of the laser pulses during the treatment, which means there is always enough time for each area of the treated cornea to cool down between laser pulses.

**Prof Marshall:** From your clinical point of view, how good should the quality of the ablated surface be? Is the SCHWIND AMARIS good enough?

**Prof Uthoff:** The surface should be of high quality and I think the SCHWIND AMARIS produces a good quality surface ablation.

**Dr Carones:** Obviously, the smoother the ablated surface, the better the clinical results are supposed to be. The intraoperative observation of the ablated surface, particularly when performing the ablation on the Bowman layer, allows the detection of a really smooth surface when compared to other lasers or even to the previous SCHWIND

laser, the ESIRIS. As large amounts of clinical results are still pending, I cannot say the surface provided by the AMARIS is good enough to provide better results, but I can say it is the best I have ever seen.

**Dr Arbelaez:** The AMARIS has a spot of 0.54mm and a Super Gaussian beam profile, which results in a smooth ablation surface that is already proven clinically with the statistically significant improvement on the contrast sensitivity after six months in groups of patients analysed during the multicentric study. In other words, if we see what happens with the aberrations after six months the preoperative higher-order aberrations (HOAs) were effectively preserved at 6.0mm, induced spherical aberration were only 0.06  $\mu\text{m}$ ; the induced coma aberrations were 0.02  $\mu\text{m}$  and induced Root Mean Square (RMS) aberrations were 0.07  $\mu\text{m}$ .



*“Dual fluence is a very smart concept. The laser uses high fluence to speed the treatment and minimise the ablation time and low fluence to ensure accuracy, smoothness and precision”*

Dr Maria-Clara Arbelaez

**Dr Barraquer:** From the evolution we have seen in laser surgery, I would say yes it is very good but without the word “enough”.

**Prof Marshall: What is your opinion about the dual fluence concept implemented in the SCHWIND AMARIS platform?**

**Dr Arbelaez:** Dual fluence is a very smart concept. The laser uses high fluence to speed the treatment and minimise the ablation time and low fluence to ensure accuracy, smoothness and precision.

**Prof Alió:** The technology that controls the thermal effect and the dual fluence concept is, in my opinion, most important from the biological point of view. The less the biological interaction with the tissue, the greater reliability we shall have in the wound-healing process. Most probably, this makes the treatment more precise and less invasive in terms of tissue trauma and probably this is why the patients see so well the day after surgery.

**Dr Barraquer:** The dual fluence concept has made a great contribution in improving performance levels by increasing ablation speed. It also allows for the possibility of including the excimer laser as an instrument to perform anterior segment procedures like lamellar grafts.

**Dr Carones:** I think that the dual fluence concept is a great solution for providing fast ablation using a very small laser spot, without compromising the quality of the ablated surface.

It looks like the Columbus egg, a very effective solution, yet easy and simple, (at least from a clinical perspective, not certainly from an engineering point of view) to a challenging question.

**Prof Marshall: The SCHWIND AMARIS offers possibilities to centre the ablation on the pupil centre, on the corneal vertex or to use the Purkinje reflex or any offset value. What is your favourite method to centre your ablation given that any one will induce tilt in the others?**

**Dr Carones:** The flexibility of the SCHWIND AMARIS is one of its best features. I usually centre the ablation at the centre of the pupillary entrance, at least for all those cases where kappa angle is smaller than 0.2mm. When the kappa angle is larger, particularly for hyperopic corrections, I use the corneal vertex as measured with my topography system (Keratron). I find it very useful and easy to use that feature of the AMARIS that allows the surgeon to enter the position of the corneal vertex.

**Prof Alió:** Centration is the most important issue that remains to be solved in corneal refractive surgery. I am using vertex centration, as the vertex is the closest reference to the theoretical visual axis. I abandoned pupil centration almost a year ago since I realised that my results were better in hyperopia. For myopia, it makes less difference but we have switched all our ablations to the vertex centration.

**Dr Barraquer:** In routine cases the line of sight (pupil centre). But sometimes it is needed to use an offset value.

**Prof Marshall: Which features have led to the most improvement in the ergonomic use of the SCHWIND AMARIS?**

**Dr Barraquer:** The SCHWIND AMARIS is a user-friendly and reliable laser because of the software, the touch screen, the controls position, the bed, the microscope and the slit lamp.

**Prof Uthoff:** The SCHWIND AMARIS allows the surgeon to operate in a convenient position. The microscope is adjustable and the operation controls are easy to reach and are clearly arranged. The additionally established slit lamp allows a better control of the interface.

**Dr Arbelaez:** The system overall is very compact, comfortable, neat and pretty and the controls are easy to reach – even for a small person like me.



**Prof Marshall:** As a matter of interest, do you use refractive surgery to treat hyperopia and mixed astigmatism?

**Dr Carones:** I went back to treating hyperopia and mixed astigmatism with the excimer laser only recently, given the very good results I obtained with the ESIRIS previously, and recently with the SCHWIND AMARIS. In my experience, the greatest advantages of the SCHWIND laser are: It has very good accuracy when treating even high levels of hyperopia and mixed astigmatism, with stable results, great quality of vision and extremely high patient satisfaction.

**Dr Barraquer:** I have used refractive surgery to treat hyperopia and mixed astigmatism since it became possible in 1997. Towards the correction of mixed astigmatism we began using the nomograms of Vinciguerra and Chayet with the Keratom II – in hyperopia our results have been always good and I presented my results at five years' follow-up at the Barraquer conference Award in 2005. With the new software the correction of astigmatism has improved enormously and nomograms are not needed.

**Prof Alió:** I use corneal refractive surgery to treat hyperopia from +7, mixed astigmatism up to +6 and myopia down to -12 spherical equivalent.

**Prof Uthoff:** I use refractive surgery to treat both hyperopia up to 4 dioptries and mixed astigmatism.

**Dr Arbelaez:** Yes I do, not as many as myopia, but so far the AMARIS is as effective to correct hyperopia as myopia.

**Prof Marshall:** Finally, to close off this part of the discussion, how important is application support and service when choosing an excimer laser system for a refractive surgery centre?



*“Interaction with the industry is mandatory. It is very important for us to have feedback from the engineers about some technical issues that affect the performance of the excimer laser”*

Prof Jorge Alió

**Prof Alió:** The support service for a well-established centre is very important. We simply cannot wait for two days to have an excimer laser repair if we have a breakdown. Today, people are very busy and

they expect a quick service. Interaction with the industry is mandatory. It is very important for us to have feedback from the engineers about some technical issues that affect the performance of the excimer laser. Immediate response following a technical problem is mandatory.

**Dr Arbelaez:** It is very important that we are able to understand all the features and applications of the laser and the diagnostic package that is linked to the system. The AMARIS is a very user-friendly system with great possibilities of customisation on the settings to accommodate the surgeons' preferences.

**Dr Carones:** Support and service is important. However, I have to say thankfully, that I have not had the occasion to call on the services of the SCHWIND support and service team, as I have not had significant problems.

**Prof Uthoff:** Application support may be important especially when you start to work with a new laser system, but it is not a criterion for me personally when I am choosing a laser system.

**Dr Barraquer:** In my opinion application and support is a key factor when deciding the choice of laser.

## Clinical outcomes

**Prof Marshall:** We should have a brief discussion on outcomes, bearing in mind that it may be a little early for you to have assessed your data since you started using the SCHWIND AMARIS. Let me begin by asking have your clinical results changed with the introduction of the new laser (SCHWIND AMARIS) in your surgeries?

**Dr Barraquer:** We have been improving our regression coefficient in obtained dioptries correction.

Actually, it is 0.965 for the whole spectre. (Myopic Compound Astigmatism 0.9796; Hyperopic Compound Astigmatism and Mixed Astigmatism 0.9505.)

**Dr Arbelaez:** Since I have started using the SCHWIND AMARIS, predictability, accuracy and reliability has increased, the recovery rate is faster and patient satisfaction is much higher.

**Prof Alió:** With the SCHWIND AMARIS we have a faster visual recovery, a faster surgical time and overall patient satisfaction has increased.

**Dr Carones:** It is too early to make final assessments on the results with the AMARIS, but I would like to note, at this stage, the lower standard deviations we get using the AMARIS, with almost no

“surprises”. I am also impressed with the greater accuracy and quality of vision that hyperopic and mixed corrections are showing with the AMARIS.

**Prof Uthoff:** The LASIK treatments with AMARIS have led to superior visual outcomes with increased patient acceptance.

**Prof Marshall: How has the SCHWIND AMARIS affected your retreatment rate?**

**Dr Arbelaez:** The retreatment rate in my patients with the ESIRIS was between 1.5 to 2 per cent. Now it has been reduced to 0.2 per cent.

**Dr Carones:** Again, it is too early to draw conclusions, at least from my experience. However, given the lower standard deviations we obtain with the AMARIS, I suspect that my enhancement rate, which was roughly three per cent with the ESIRIS, will become smaller with the AMARIS.

**Prof Alió:** At the time of this discussion, I have not had any retreatments with the AMARIS. I have not been using the technology for a sufficient period to allow me perform a valid assessment of retreatments.

**Prof Uthoff:** The retreatment rate seems to be lower than with other lasers, which we have used earlier.

**Dr Barraquer:** It is too early to answer that question.

**Prof Marshall: Have you performed retreatments with the SCHWIND AMARIS laser? What have your clinical results been so far?**

**Dr Arbelaez:** Yes, I have – mostly corneal wavefront; if we compare the data, they are very similar to the results with aberration-free in virgin eyes.

**Prof Uthoff:** Until now, we have not performed any retreatments.

## Customised solutions

**Prof Marshall: We will now discuss customised solutions. How many treatments (in approximate percentage) do you perform as customised ablation versus aberration-free treatment?**

**Prof Alió:** All of my treatments are customised on asphericity (aberration-free treatment) when they undergo the initial surgery. For

retreatments, if I have any level of significant corneal aberrations with an impact on the global aberrometry, then I perform corneal wavefront-guided methods unless global aberrometry is neutral. Sometimes you have internal correction of the corneal aberrations and this has to be taken into account when performing the treatment, either custom-guided or global wavefront guided.

**Prof Uthoff:** We perform 10 per cent customised ablation versus 90 per cent aberration-free treatments.

**Dr Carones:** Aberration-free treatments are extremely accurate and effective, and they represent my standard for laser vision correction on normal eyes. I customise those treatments where significant levels of HOAs are present, and this represents no more than three per cent of my cases.

**Dr Barraquer:** We use as standard OZ 6.0 or 6.5mm in myopia treatment; in such areas, ablation depth becomes very important; aberration-free treatment (aspherical) has the advantage of decreasing the amount of tissue ablated to correct an ametropia. Routine patients in laser correction are quite normal eyes without HOAs.

**Dr Arbelaez:** Reviewing a group of patients I found 70 per cent aberration-free, 20 per cent ocular wavefront and 10 per cent corneal wavefront.

**Prof Marshall: What are your patient criteria for using customised ablation versus aberration-free treatment?**

**Dr Carones:** For normal, virgin eyes, I customise the treatment only in those cases where significant levels of HOAs are detected at corneal topography or total wavefront analysis. For all those “symptomatic eyes”, that are usually eyes which have already had laser vision correction, post-traumatic eyes, etc., I take into consideration what the patient says about the quality of vision, and obviously I consider as well the amount of HOAs. Again, it is not a decision that can be easily generalised with indications at-large; it is more an eye-to-eye decision.

**Dr Barraquer:** My patient criteria for using customised ablation versus aberration-free treatment are the aberration map (corneal or ocular) and the ablation depth. In general the aberration map with HOAs more than 0.5  $\mu\text{m}$  at 6mm is analysed to search the origin and location of the defect; if aberrations are in the cornea, we use the CW program, if not, the OW software.

**Prof Uthoff:** This depends on the amount of aberrations we have found. We use it especially in higher-order operations.



**Dr Arbelaez:** With values of RMS > 0.35 microns at 6mm and Best Spectacle Corrected Visual Acuity (BSCVA) < 20/20, I recommend ocular wavefront, if there is a measure with at least a pupil of 6mm or more; corneal wavefront in case pupils smaller than 6mm, and retreatments.

**Prof Marshall: What have your results been using the customised corneal wavefront treatment?**

**Dr Barraquer:** The refractive correction and the quality of vision are very good in such difficult cases. We use it mainly, to perform corrections over radial or astigmatic keratotomies, corneal grafts, high astigmatism.

**Prof Alió:** Customised corneal wavefront treatment has been the issue of our clinical research for the last three years and we have published several papers on the topic<sup>1</sup>.

We are able to treat the problems of both our patients and those referred to us. We can correct high levels of coma and spherical aberration. Now we know how to distribute the correction in order to be more flexible and adapt to patients' needs. In addition, we have avoided many corneal grafts in patients with highly symptomatic corneas that otherwise would have been impossible to treat, as global wavefront sensors simply cannot measure moderately to high-aberrated corneas.

**Dr Carones:** Our results have been great. I just want to make one very simple comment.

Corneal wavefront custom treatments are not able to smooth or polish a rough corneal surface, as it is commonly believed. They do not act as a phototherapeutic keratectomy. They reduce those higher-order aberrations generated by the irregularities. This means that they are indicated only for those cases where corneal wavefront analysis shows significant levels of HOAs. Thus, it is mandatory to have this analysis even before considering this approach, in order to have satisfactory results.

**Prof Marshall: What have your results been using the customised ocular wavefront treatment?**

**Prof Alió:** Customised ocular wavefront treatment is only used when we have significantly high global aberrations in the absence of high levels of corneal aberrations in a retreatment case. We do not use global wavefront-guided treatments for primary cases, as there is a consistent body of evidence that we change the aberrations of the cornea in the first surgery. We prefer to tell the patient that we shall make a two-step approach. During the first surgery we shall correct the refractive error with an aberration-free optimised treatment (aspherical treatment) while in the second step, we shall correct the

minimal amount of refractive error and then the global aberrations.

**Dr Barraquer:** The results of the OW software in SCHWIND technologies are very good, not only in terms of refractive correction, but also the quality of vision.

**Prof Marshall: What has been your experience with using the SCHWIND AMARIS laser in highly aberrated eyes?**

**Dr Barraquer:** Our experience has been good. You must make the analysis of where the aberrations are placed, and treat the patient with the correct software.

**Dr Arbelaez:** The laser is effective and there is always improvement even in difficult cases, such as patients with previous corneal transplants etc.

**Prof Marshall: Are there any advantages to coupling corneal wavefront data with those obtained from an aberrometer?**

**Prof Uthoff:** The aberrometer measures every variation of the entire optics of the eye from the cornea, to the retina. On the other hand, the coupling corneal wavefront provides us with additional information on the occurrence and origin of aberrations i.e., either from the lens or from the cornea. This helps surgeons to decide if lensectomy or corneal surgery is the procedure of choice.

**Dr Barraquer:** It is very useful as a diagnostic parameter – it tells you exactly how to proceed: which laser software to use and to decide between laser refractive surgery, phakic lenses or phacorefractive procedures in the cases that require analysis.



*"The advantages are more in the diagnostic area than in the therapeutic one. This coupling allows for a precise diagnosis on the origin of higher-order aberrations, either corneal or internal"*

Dr Francesco Carones

**Prof Alió:** The advantages to having corneal wavefront and global wavefront data are outstanding as we understand better what to do and where.

I am not convinced that to correct in the internal aberrations of the eye on the cornea makes sense unless in the pseudophakic patient.

**Dr Carones:** The advantages are more in the diagnostic area than in the therapeutic one. This coupling allows for a precise diagnosis on the origin of higher-order aberrations, either corneal or internal. However, my clinical experience shows that 90 per cent of the aberrations in the majority of cases are generated by the cornea. Regarding the final decision as to what to consider for planning a custom treatment, I think that the information generated by the corneal wavefront has to be considered in the very vast majority of cases.

**Dr Arbelaez:** Of course, in an aberrated eye, you can see where the main problem is and decide the best option of treatment.

**Prof Marshall: Finally, to close this round of questions, how important are additional functions of an aberrometer, for example, wavefront accommodation assessment or integrated pupillometry?**

**Dr Carones:** These provide useful information, but are not mandatory. I consider them as additional options and gadgets that everybody would like to have, but they are not crucial.

**Dr Barraquer:** Any function that allows the doctor to make a better decision or that could make more “intelligent” software able to recommend the best optical zone, is welcomed.

## Eye tracking with SCHWIND AMARIS

**Prof Marshall: Let us now move on to discuss eye tracking with SCHWIND AMARIS. What is your experience concerning the importance of five-dimensional tracking?**

**Dr Barraquer:** I can only answer based on the actual results: they are good. With SCHWIND technologies we have always had control of the eye's movement; first it was a passive fixation tracking but its technology has been improving and evolving until now, so we can control not only the patient's fixation but also the static and dynamic cyclotorsional movements of the patient's eye. I have not yet analysed in detail the five-dimensional eye tracking in the refractive results.

**Dr Carones:** This is my favourite feature of the AMARIS. I found the tracker astonishing not only as regards the technical features (fastness, latency, five-dimensional eye tracking, etc.), but especially in driving the very good results with low standard deviations I am obtaining with this platform. The AMARIS eye tracker first introduced the possibility of compensating for rolling movements, both by recalculating the exact displacement when an eye rolls during the ablation, and compensating for the right amount of energy to be delivered with respect to that displacement, and I think that this particular feature is at the basis of the great clinical results. The accuracy of the detection of the point

where it is to be centred, as soon as the tracker is engaged just prior to the ablation, also is extremely good.

**Prof Uthoff:** We use the five-dimensional eye tracking in every case and we have the feeling that especially in higher astigmatism, this is a great advantage.

**Prof Marshall: From a clinical point of view, how fast should an eye tracker be? Is the speed of the SCHWIND AMARIS eye tracker fast enough?**

**Prof Uthoff:** From my clinical point of view, the eye tracker of the SCHWIND AMARIS is fast enough considering the fact that it is much faster than the spontaneous movement of the eye.

**Prof Alió:** The eye tracker should be at least double the speed of the ablation rate. The SCHWIND AMARIS provides an excellent speed of ablation and so is the tracking as it fits this role.

**Dr Barraquer:** In my opinion, an eye tracker should be faster or equal to eye movement.

**Dr Carones:** There are two figures related to eye tracking speed, detection time and latency (or response time). The detection time of an eye tracker dedicated to excimer laser refractive surgery should be at least twice as fast as the repetition rate of the laser. With the AMARIS and its 500 Hz repetition rate, the tracker acts at 1050 Hz detection rate, which seems fast enough. Ideally, the latency should be zero and this is impossible. With the AMARIS, we have 3 ms latency, which is the lowest on the market, and fast enough to guarantee minimal spot displacement.

**Dr Arbelaez:** The eye tracker should be at least twice the speed of the laser. The SCHWIND AMARIS has a 1050 eye tracker speed. That is fast enough.

**Prof Marshall: How important is the combination of static and dynamic cyclotorsion control for obtaining highly precise and predictable results? Which feature is more important in your daily practice – static or dynamic cyclotorsion control?**

**Dr Carones:** This combination is crucial when attempting customised ablations, where the asymmetrical ablation pattern has to be perfectly aligned to obtain reduction of higher-order aberrations, and very important when correcting relatively high amounts of cylinder (let us say, above 1 dioptre). For aberration-free corrections with less than 1 dioptre of cylinder, I believe that dynamic cyclotorsion control may be enough to guarantee highly precise and predictable results.

On a daily basis, I consider dynamic cyclotorsion control as more important but this is only if I have to choose between the two. I think



that only the combination of the two, after careful single-case selection, may lead to the same predictable results.

**Prof Alió:** The combination of static and dynamic cyclotorsion renders a much more precise and predictable result and I consider both important for my practice. It simply adds more precision to my ablation profile.

**Prof Uthoff:** I consider this to be of great importance because we find differences up to 30 degrees in patients from upright and lying positions. Especially in astigmatism, the cyclotorsion control is of great importance.

For daily practice, static cyclotorsion control seems to be of more importance in cases with higher astigmatism.

**Prof Marshall:** Did you observe significant torsional differences in eye positions between a patient in an upright and a supine position?

**Dr Barraquer:** We have always been careful in considering head position during laser treatment. We actually take much more care in the topographic head position. In the first cases, we found differences up to 6.0°.

**Dr Carones:** I do not think the differences are significant. A torsional difference in eye position may be greater than five degrees in, let us say, five per cent of the patients I examine. However, as I said, this five per cent torsional difference may result in a suboptimal result when attempting customised treatments, or when attempting high-astigmatic corrections, and this is why I believe it is mandatory to compensate for this difference when attempting this kind of ablation.

**Prof Uthoff:** Our experience is that there can be a big difference between patients in upright and supine positions, which can be up to 30 degrees.

### *The SCHWIND AMARIS and challenges in refractive corneal surgery*

**Prof Marshall:** This has been a very interesting discussion. Before we conclude our debate, I would like to ask you about challenges and developments in refractive corneal surgery and invite you to give me your views on how the SCHWIND AMARIS can help you to meet these challenges.

**Prof Alió:** In my current refractive surgery practice, our major challenge is to optimise presbyopia treatment. We already have created the concept of presbyopia correction with the PresbyMax software that will improve our results in early and intermediate presbyopia. We

think that in the future we shall be able to implement the software for advanced presbyopia as well. Anyhow, this is an issue still under clinical investigation in our clinic.

Today, what we have as the most important issue in refractive corneal surgery is indeed the 6th generation concept of excimer lasers. We have more precision at all levels, better outcomes and better technology to correct our refractive errors. We are expanding the limits of our refractive corneal correction thanks to the use of much better ablation profiles, with the visual optics and ablating less tissue. We can correct aberrated corneas. The use of femtosecond lasers or mechanical microkeratomes such as the Carriazo-Pendular with planar flap creation has been indeed a major step forward as we control this important step in the surgery.



*"In my opinion, the most groundbreaking product/feature in the future of refractive surgery will be in intracorneal surgery"*

Dr Carmen Barraquer

**Dr Barraquer:** I think the biggest challenge we face in our refractive surgery practices is to be able to respond to the high expectations of patients. The most important contribution a surgical equipment company can make towards helping us in meeting this challenge is to carry out research to improve its own software and hardware.

In my opinion, the most groundbreaking product/feature in the future of refractive surgery will be in intracorneal surgery.

**Dr Carones:** The biggest and most important challenge I face is presbyopia correction. There are several methods to partially manage this challenge, like monovision, excimer laser presbyopic ablation, intraocular lenses, scleral expansion segments, intracorneal stromal inlays, etc., and although I have used all these approaches to manage selected cases, I feel that currently there is not one method able to really correct presbyopia without inducing some significant compromise either in the efficacy of the correction, or in the quality of vision.

In terms of groundbreaking products, definitely, for a laser company the most desirable equipment would be a laser/software able to provide at least 1.50-2.00 D of presbyopia correction without significantly compromising distance vision and visual quality. Lens manufacturing companies should consider the benefits of an intraocular lens able to correct slightly more (2.50 to 3.00 D), and again without compromising distance vision and/or quality of vision.

**Prof Uthoff:** We are very interested in presbyopic laser surgery, which is one of our major challenges. Surgical equipment companies can help us in establishing special software programs and of course correct nomograms.

The most groundbreaking product/feature in the future of refractive laser surgery would probably be the correction of presbyopia by multifocal cornea. This should lead to pseudo accommodation effect for near vision without any discomfort for far vision.

**Prof Marshall:** Thank you all very much for your contribution to what has been a very stimulating discussion. I would like to thank SCHWIND for facilitating this roundtable debate which has allowed us to look at some of the exciting advances that are happening in laser technology, and in particular with the SCHWIND AMARIS. I think our take-home message should be that while we are lucky to have excellent technology at our disposal, the challenge to SCHWIND and to other manufacturers is to continue their research and development programmes, in consultation with refractive surgeons, so that we can respond to the expectations of our patients.

<sup>1</sup> Alió J, Galal A, Montalbán R, Piñero D. Corneal wavefront-guided LASIK retreatments for correction of highly aberrated corneas following refractive surgery. *J Refract Surg* 2007; 23: 760-73.

Alió JL, Piñero D, Muftuoglu O. Corneal wavefront-guided retreatments for significant night vision symptoms after myopic laser refractive surgery. *Am J Ophthalmol* 2008; 145: 65-74.

Alió JL, Piñero DP, Plaza AB. Corneal wavefront-guided enhancement for high levels of corneal coma aberration after laser in situ keratomileusis. *J Refract Cataract Surg* 2008; 34: 222-31.

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