From Eye to Insight

Leica MICROSYSTEMS

Summary from an Ophthalmic Surgical Panel Discussion in Japan

TAKING AN IN-DEPTH LOOK AT THE ILLUMINATION & OPTICS OF THE PROVEO 8 OPHTHALMIC MICROSCOPE

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With the thought of taking an in-depth look at Proveo 8 Ophthalmic Microscope from Leica Microsystems, Prof. Kei Shinoda invited four **surgeons, all experts in optical performance and microscope systems**, to talk about the Proveo 8 ophthalmic microscope from Leica Microsystems. Further the group discussed topics like, the future of ophthalmic surgery and the role that microscopes will play in it.

The **panel discussion** brought very interesting and valuable insights on the Proveo 8, e.g. how the microscope supports surgeons in their daily work by revealing more details due to its excellent illumination system. Particularly **the optical concept and the overall user experience of the Proveo 8** have been discussed in detail during this event.

This report reflects on the panel discussion and illustrates the benefits of the illumination concept and optics of the Proveo 8 ophthalmic microscope. You can **find answers** on questions like: **How does the Proveo 8 deliver such large amounts of light to the surgeon. Why is illumination so important for surgeons and patients alike?**

Dr. Shunsuke Osawa
Clinic Director, MIE Eye Clinic

Dr. Toshiaki Kurakazu
Clinic Director, Hangai Eye Institute

Dr. Masayuki Shibuya
Assistant Professor, Saitama Medical University Hospital

Dr. Tatsuhiro Nakamura
Clinic Director, Nakamura Ganka Clinic

“PROVEO 8 PRODUCES AN EXTREMELY RELIABLE RED REFLEX, NO MATTER WHERE THE PATIENT IS LOOKING AT.”

Shinoda

Let’s start with the brightness and safety aspects of the microscope. **The Proveo 8 is often described as a “bright microscope”. What does this mean?**

Osawa

The Proveo 8 produces red reflex from any angle, right?
That’s quite incredible. Patient can look slightly to the right or up, there is still a **reliable red reflex**. **For** me as **a surgeon** that is very beneficial, as I can simply get on with my work. **That’s great!**

Shinoda

The key seems to be having **0°-coaxial illumination from four LEDs.** Although 0°-coaxial illumination has become an established technique and a benchmark for other manufacturers, a 0°-coaxial illumination like Proveo 8 has, is hard to find in other microscopes.

Some microscope manufacturers produce red reflex with 0° illumination but **combine it with oblique illumination**. They set the beam at a slight angle, to provide a three-dimensional effect.

Leica Microsystems has put more thoughts and attentiveness into the illumination concept of the Proveo 8. They **realized that a stable Red Reflex is very important**, I guess that’s why they developed this illumination in the first place.

Nakamura

Even if the nucleus is hard or cloudy, it still produces red reflex amazingly.

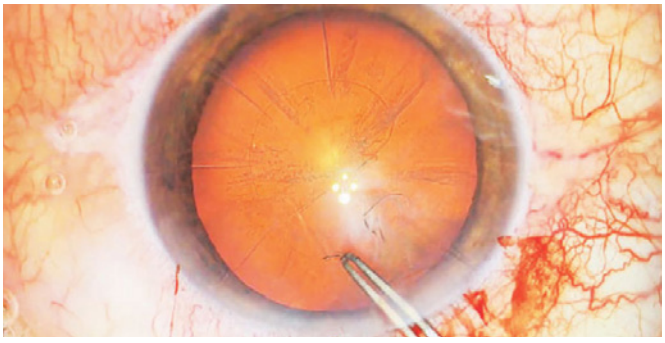


Fig. 1. Red reflex under Coaxial 0° illumination (CoAx4) with four LEDs.

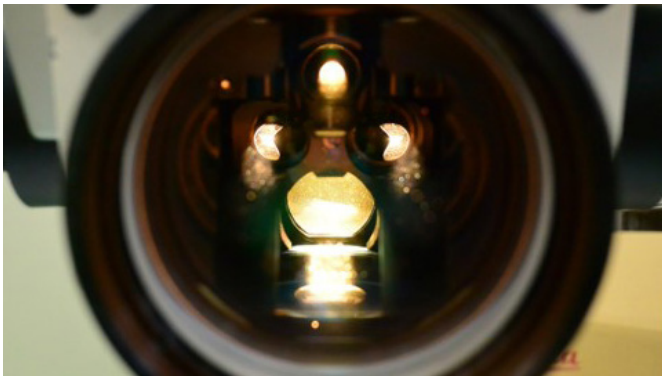


Fig. 2. Coaxial 0° illumination (CoAx4) with four LEDs.

Kurakazu

If we're talking for instance about a standard cataract procedure or capsulorhexis with lower complexity, a younger doctor would probably not notice a big difference in the **quality of the red reflex with Proveo 8**. But with more severe posterior capsule opacification or mature cataracts, I think they will **notice the difference and appreciate it** highly. Especially if they start working on **cases, where the red reflex can't be obtained easily.**

Osawa

With vitreous hemorrhages and so, yes!

Kurakazu

Exactly. You can really see and perceive the red reflex nicely on the surface of the anterior capsule if you change the angle of the eye a little. When you do an **incision in the anterior capsule**, using the Proveo 8, **you get a very spatial and three-dimensional image** of the anterior capsule. Conventional full red reflex-type microscopes only tend to show the shadow of the anterior capsule. It's really great, how a microscope like **Proveo 8 supports and transforms surgical procedures**.

In difficult cases, the location of the anterior capsule needs to be properly identified. I believe, that the approach with using the red reflex to make an anterior capsule incision could be also useful for procedures like an inner limiting membrane removal or a MEM (macular epiretinal membrane) surgery. If you have the choice you would always want to **see the anterior capsule itself, and not just its shadow, no matter how experienced you are as a surgeon.**

Shinoda

But what about three-dimensionality? So far this has mainly been the job of an oblique illumination. And as we know oblique illumination has an angle. So does the Proveo 8 have no conventional oblique illumination? **How is a three-dimensional image then assured?**

Kurakazu

Even with coaxial 0°-illumination, you can get a shadow contrast with the diffused light from the LEDs. I guess it's a similar **principle** like with coaxial diffused illumination methods of industrial microscopes. According to this concept, the light beam points straight down, but emerges from different angles. Looking through the microscope through the right and left optical paths a firm shadow can be seen even with coaxial illumination.

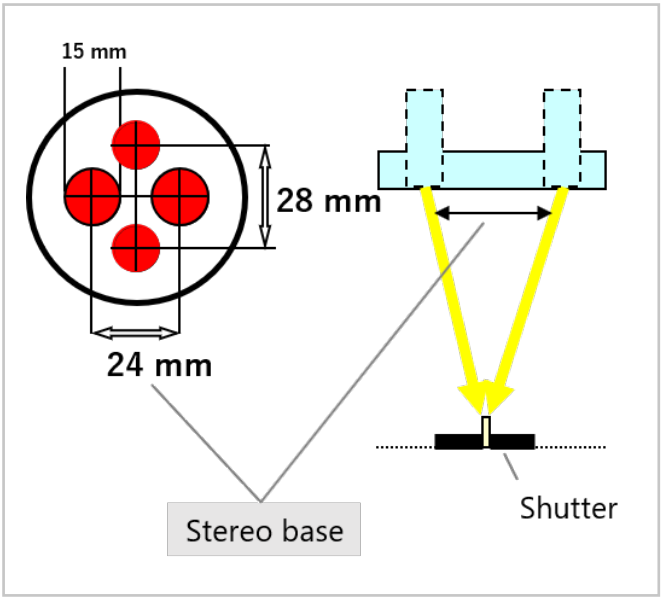


Fig. 3. Optical concept of the Leica Stereo base

Osawa

The distance between the optical paths for the left and right eye is 24 mm with the Proveo 8. This is **incredibly wide.** We call it the optical path width or **stereo base**. You know: The wider the distance btw. beam paths the more shadow/contrast gets emphasized, **which makes it easier to perceive three-dimensionality**.

With regards to **"shadow-producing" illumination**, I guess we can say that **all four LEDs serve as an oblique illumination**, right? The main LED is much larger than the other three and sheds light over a wider area.

Shinoda

Three red reflex LEDs plus the main LED gives a total of four. Apparently the red reflex LEDs and the main LED can each be controlled separately.

EASILY CUSTOMIZE

You can even **pre-define light settings for certain procedures and activate them via footswitch** control easily during surgery. I'm talking about the Combination Mode feature. Do you all use it?

Kurakazu

I use the **CombinationMode**. You can program several phases: I have saved a few modes that **fit well to the most common or recurring situations of my work.**

For instance: I turn off the red reflex before I go into the vitreous body, so I have one setting for that. Once I've started on the vitreous body, I use the main LED to light the entire field of view, which makes e.g. the conjunctiva easier to see, while I am working. It's nice being able to **adapt settings quickly to situations**. With one tap on the footswitch, I simply switch to a broader lighting when I suture, for example.

Nakamura

I've been using it too recently. When I reach the conjunctiva, I switch to a darker light setting and then back to more light during the cataract procedure. **Switching fast between light levels makes life easier, also for the patient.**

Shinoda

So, if you want to change the illumination because, say, the reflex is dazzling, you just tap on the footswitch, you mean?

Kurakazu

Yes. It can be **important to adjust the main LED for the patient** when the reflex is dazzling. If you lower it, it can **take away discomfort**. And imagine glaucoma surgeons, I guess it's really difficult to work with full coaxial illumination for cataracts, so being able to switch easily and fast between illumination settings is great.

Osawa

Surgeons who say that the reflex is too dazzling with the Proveo 8 have in many cases probably chosen an illumination level that is to bright. It's actually one of the **advantages of Proveo 8: even under reduced light levels you still get a great red reflex**. It's really important for people to understand that.

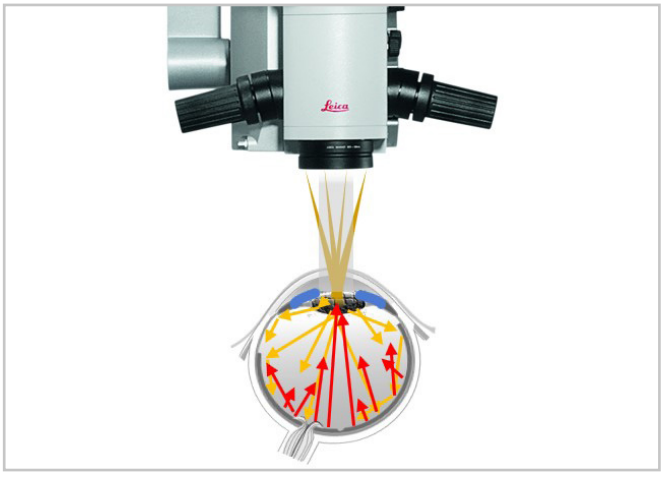


Fig. 4. Creation of a stable red reflex thanks to CoAx 4, coaxial LED illumination.

Kurakazu

Furthermore: if the m**icroscope illumination is set too bright**, the **reflexes** of the conjunctiva **or** the **residual water** scatter the light and **make it difficult to see**.

Nakamura

Apparently, **some** surgeons **say that increased brightness is tiring** for the eyes. I think that comes more from **the fact** that they have **poor diopter adjustments.** When I first used the Proveo 8, I got tired myself. Now, I know that I hadn't managed the diopter settings correctly. When I checked the monitor later, I saw that I had been operating with the microscope pretty much out of focus.

The Proveo 8 has an **incredibly deep depth of field** and a good balance between resolution and three dimensionalities. This allows surgeons to **see clearly and operate without having to interrupt their workflow** frequently to refocus. Once I knew how to choose settings most efficiently my tiredness was gone.

You probably know that today most surgical **microscopes have filters** supplied t**o reduce the brightness** of the LEDs, in order to display things in soft, yellow tones. Well, to be honest **I don't need them**. At first, I found the Proveo 8 illumination a bit too white and bright, but I got very quickly used to it.

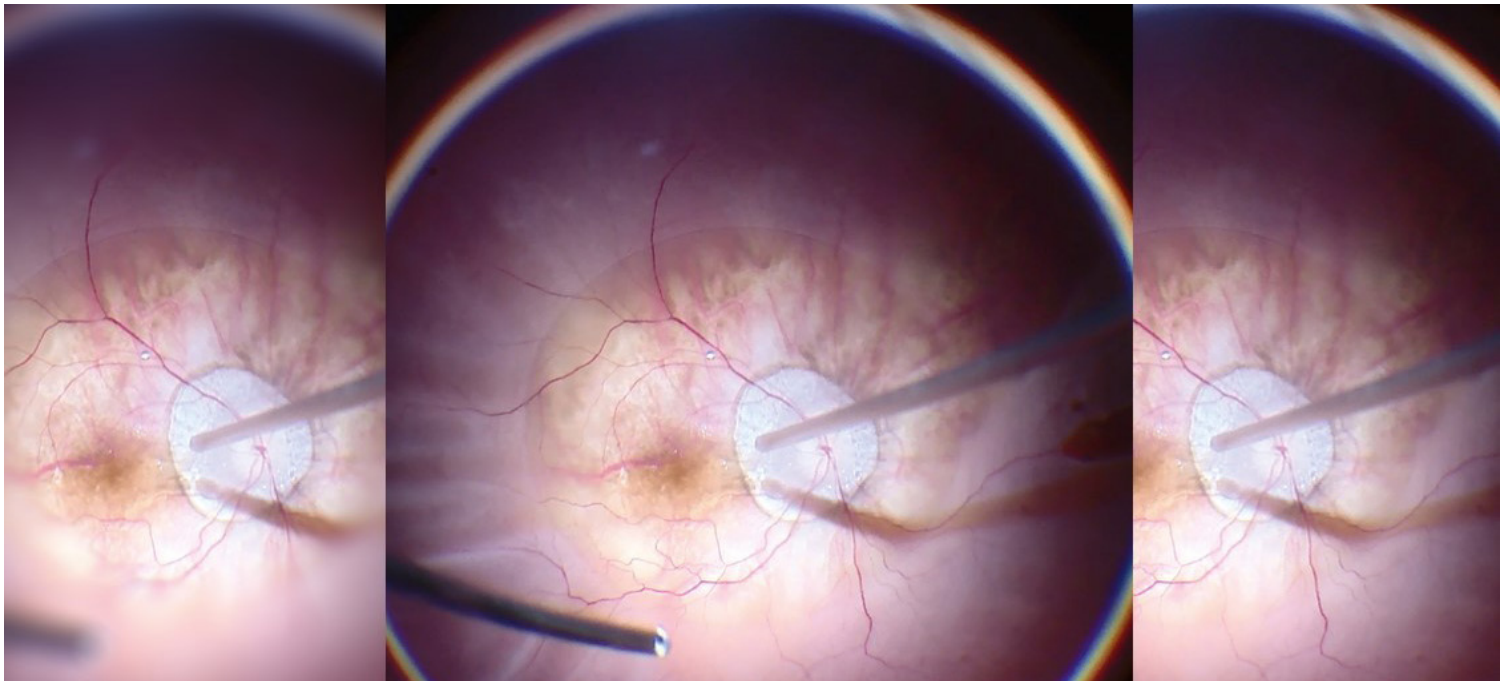
Kurakazu

For me it's the other way around. I'm not keen on white colors. I've always worked with yellows. It really depend on your own preferences, and what you are used to. For new users of Proveo 8, I **recommend** first **adjusting** the **dimming and color settings** of the microscope **to** their **individual needs**.

Osawa

Preprogramming settings is important. And we're not only talking about illumination settings. **Compatibility** with other OR devices is also **important**. And this is different for every microscope. When you start using NGENUITY* for example, you need to **program** this **accordingly**, otherwise you don't get the view you want.

*Ngenuity is a brand of Alcon, a Novartis Division



IT'S OBVIOUS!
THE PROVEO 8 "WASTES NO LIGHT"

Shinoda
With the help of some medical colleagues we made **a comparison of the volume of light reaching the cornea using the Proveo 8 and other microscopes**. The brightness was set according to individual preferences for all microscopes.

Shibuya
Surgeons obviously have their own preferences. However, all our test surgeons chose same light intensity levels regardless of the microscopes they worked with. And yet, when we measured and compared how much light was reaching the patient in each case, it was much **lower with the Proveo 8.**

Shinoda
So, we realized, there is a big **difference** between the **light** that the **surgeon is seeing** and the light that the **patient is seeing**.

Osawa
I very **rarely** hear **patients complaining** about the **light** being **too bright.** They are moving their eyeballs though due to the Bell's phenomenon.

Kurakazu
What we think we know, based on common sense, isn't always true though. If you use the **Proveo 8**, it could **change the way you think**.

Osawa
If you look at it from the optical point of view, it is quite clear that the **Proveo 8 is very bright**. The **lens design** and the conception of the **optical paths** have been **very carefully thought through** to keep light loss to a minimum.

Shinoda
That's true. On the **Proveo 8**, there's a camera in the assistant's optical pathway, right? This obviously makes the **surgeon's visual field brighter than** in the type of microscope **where light is dispersed from the optical pathway of the surgeon to the camera**. If the light is dispersed from the surgeon's end, the light coming back to the surgeon is always going to be reduced, no matter what you do.

Osawa
The **assistant can see exactly the same image as the main surgeon,** which is why the camera has been put on the assistant's observation path. Assistants can also see the red reflex, which is **great for teaching**, right?

Shibuya
We're a teaching hospital, and our aim is to train specialized surgeons. So, the fact that the optical path for the assistant is showing the same image as for the main surgeon, who has, like everybody thinks the better image, **is actually great.** We're not training people to be specialist assistants, after all...

Osawa
I, on the other hand, do the surgery on my own. I don't need an observer tube attached, so I've asked them to take it off...
If that's all right! (laughs)

Shinoda
Is it normal that **approx. 30%** of the light that comes back to the surgeon is **sacrificed to the camera?**

Osawa
Yes. So, it's incredible to be able to **see with 100% of the light**! This is especially **important** when working, on the **vitreous body**.

Nakamura
I recently **changed the objective lens** from a 200 mm working distance (WD) one to 175 mm WD - I have a much **brighter image now**.

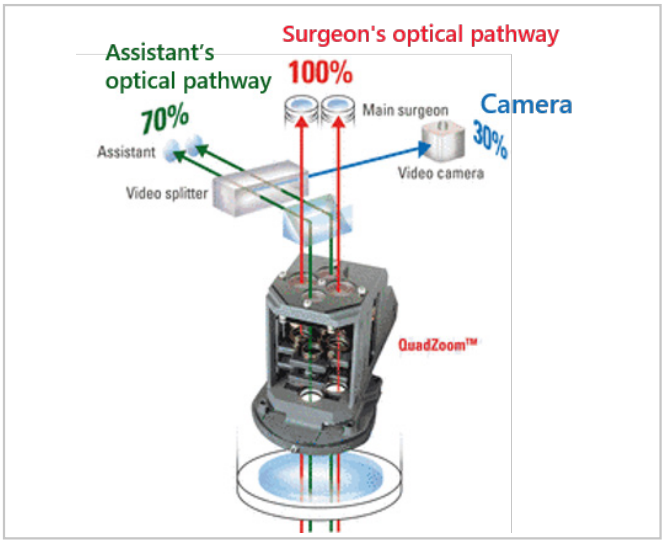


Fig. 5. Optical concept of the QuadZoom from Leica Microsystems.

Shinoda
Does the **objective lens** really make a **big difference?**

Nakamura
The **focal length varies from lens to lens**, so the **brightness** will **change as well**. The shorter the focal length, the lower the F-value that indicates the brightness of the lens. **The lower the F-value, the brighter the lens**.

Kurakazu
We've always used a lens with a WD of 175 mm, because we had a lot of female surgeons. They said that the shorter working distance was easier for them to operate with.

Shinoda
How is the **optical performance** of objective **lenses from Leica**?

Osawa
Going back to the topic of stereoscopic vision, since the **stereo base is so wide** it is a **huge advantage** that the **Leica lenses are so big.**

Shinoda
You mean the large-diameter objective lenses?

Osawa
Yes, the lens is big, so **it's bright**. Light entering through the objective lens comes back to the surgeon and splits into two optical pathways. In the brain the surgeons then recombine the light that is received into one image. It is easier to get an **impression of three-dimensionality** and distance **if the microscope has a large optical path width.**

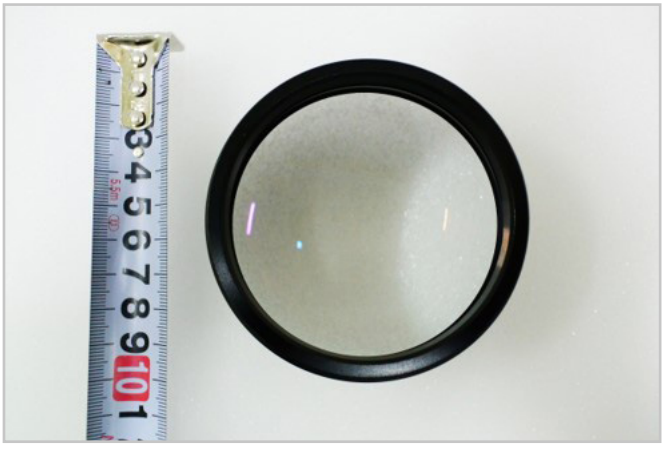


Fig. 6. A large-diameter objective lens (68 mm across)

Kurakazu

Humans usually see **different images with their left and right eye.** Their **brains merge these** into one three-dimensional image. If there's too much discrepancy between those images our brains can't fuse them together. However, the rule essentially is the greater the discrepancy the easier it is to get the **impression of three-dimensionality**.

Shinoda

The pictures and videos taken with the microscope are also incredibly clear. Is this also due to the lens?

Osawa

Yes, the **absence of blur and low distortion** are also due to the **great performance of the lens**!

Kurakazu

I get often asked why my microscope images are so clear and how I've captured them. My answer is: I do nothing special; I just take the pictures with the Proveo 8!

Leica's lenses are big, mainly because of their thickness. The fact that the lens is thick implies that **Leica uses glass with a low refractive index, which results in a higher Abbe number.** The higher the Abbe number, the clearer the lens and the less chromatic aberration it has.

Fig. 7. A thick objective lens with low chromatic aberration.

Shinoda

Let's quickly talk again about the r**ecombination of the different images by the brain**. Leica Microsystems uses this phenomenon for its **FusionOptics Technology**. Purposefully showing the right and the left eye different images, getting the brain to cleverly fuse them together.

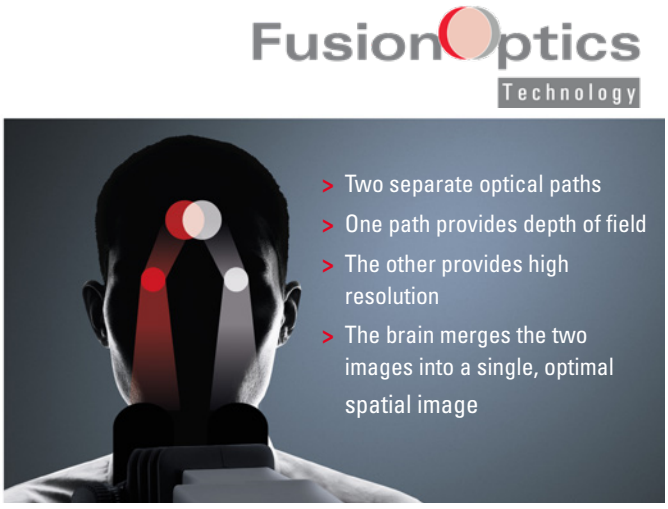


Fig. 8. The FusionOptics technology from Leica Microsystems.

Nakamura

It's about depth of focus (DOF) and resolution. **Microscopes with a larger depth of focus are easier to focus and give better visibility.**

Osawa

However, in terms of **standard optical theory**, it is not possible to increase **resolution and extend depth of field** at the same time. The two features **behave proportionally inversely** to each other, so that a limit value exists. A microscope can only emphasize one or the other can be manufactured.

Kurakazu

So, what Leica does is the following: They are showing an image with large depth of field and one image with high resolution to one eye each and have them fused by the brain.

The images that each eye sees individually are not meaningful, but once they are fused in the brain, an image results that represents the

best of both worlds: **High resolution with great depth of field.** The idea of leveraging on these human brain qualities and thus overcoming theoretical limitations was the birth of the **FusionOptics Technology** at Leica Microsystems.

Shinoda

The fusion of two projections in the head is therefore **absolutely natural and not a problem** for humans. It does not bother us at all.

Nakamura

I've also been curious and asked myself how this works in the Proveo 8. So, what's happening is the following:

The optical pathway of the right eye incorporates a diaphragm to reduce the numerical aperture, which enables you to see images with a large depth of focus. On the left eye, the numerical aperture is made as high as possible to emphasize the resolution. In this way, **depth-of-field and resolution information can be perceived by the brain in a balanced ratio and successfully merged together.**

Shinoda

How does FusionOptics work when you're using NGENUITY?

Osawa

The trick is to focus with the left eye first. The left eye has the higher resolution, so it is a good idea to focus on the target.

Nakamura

Given that color and brightness are quite different on the left and right.

Osawa

It's fine if you use it properly. I think it's useful when you're doing surgery with NGENUITY too.

I mean, the Proveo 8 system itself works exceptionally well with NGENUITY, right?

Because you get amazing magnification when you view the image on the monitor. Like, multiples of ten. When you magnify something, it gets darker anyway. The optical system of the microscope itself has been designed to be able to gather this much light. There are many difficult situations in which Proveo 8 can really support surgeons.

Shinoda

I personally wouldn't know whether it was designed with 3D heads-up surgery in mind from the start, but what we are saying is that, **at the end of the day, the Proveo 8 really is a good match for new emerging surgical procedures.**

CONCLUSION AND KEY POINTS TO REMEMBER

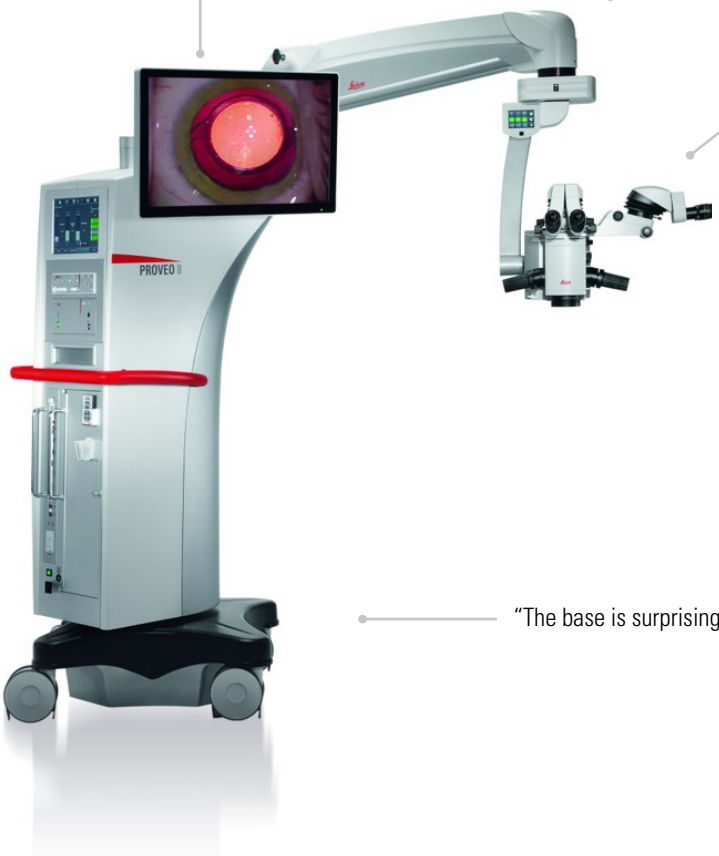
With ophthalmological microscopes we observe the light reflected back from the fundus, which produces a red reflex. In cases with a diffuse reflection, where the light loss is high, a good red reflex cannot be achieved. Optics manufacturers around the world are trying to find solutions that eliminate the light loss. And they are already doing this very successfully in surgical microscopes!

For an ophthalmic surgeon an intutive hand-eye-coordination, or in other words an intuitive sense for distance and depth is a key factor when operating with a microscope. Surgeons want to be able to apply their surgical skills precisely and accurately with confidence. The Proveo 8 provides surgeon a large field of view with great depth perception. From peers we've heard that they didn't experience any problem of orientation, they said they could work intuitvely and got a good sense of the distances and depth while operating.

FURTHER FEEDBACK & RECOMMENDATIONS FROM PROVEO 8 USERS ...

"We regret that we didn't include a monitor in the configuration of the Proveo 8 right away."

"The long arm has been received very well by everyone in my team"



"The red reflex can also be seen on the assistant's microscope - this is great for teaching."

"The base is surprisingly small."

These product features embody the skills, experience and passion of Leica:

> Full coaxial illumination (0° illumination)
> LED direct illumination
> Optical path width (stereo base) 24 mm
> Optical pathway 15 mm
> FusionOptics Technology
> Quad Zoom
> Large-diameter lens (68 mm across)

Other systems and accessories that you can add:

> Wide-angle observation system
> High-magnification adapter
> Intraoperative OCT (for the anterior and posterior eye)
> Surgical guidance

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Class I surgical microscope Proveo 8

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