Cassini topography review: Topography of the 21st Century

Matthew Swanic, MD
The Las Vegas Eye Institute

Dr. Swanic is a Cornea and Refractive subspecialist who performs advanced cataract surgery, LASIK, and SMILE at his own private practice, the Las Vegas Eye Institute.

Background

Many of the members of the forum Soloeyedocs are aware of my use of the Cassini topography system and my strong belief that it is a very helpful device for the evaluation of cataract patients. I also find that it blends very nicely with the Haag Streit Lenstar device as they both offer highly repeatable keratometry values. This article will go into much greater detail about my experience with these devices but primarily focusing on the advantages Cassini has brought to my cataract and refractive practice.

I had the pleasure of getting involved with the Cassini multicolored LED topography system over four years ago when I was told about how they had created one of the major advancements in corneal analysis of the 21st century. Specifically, Cassini had the ability to analyze posterior corneal curvature in a fast, accurate, and repeatable manner. In its original form it did this by reflecting 7 infrared dots off of the posterior cornea. This would be similar to how the original IOLMaster determined anterior corneal power by reflecting 6 dots off of the anterior cornea. Many people say, “but wait Pentacam and Galilei allow posterior corneal analysis through the use of their dual Scheimpflug technology.” This is true but unfortunately the resolution of these cameras is not high enough to accurately and repeatably determine true

posterior corneal curvature. Many of us remember when the Pentacam was removed from the ASCRS post myopic LASIK calculator because of its poor performance for measuring the anterior cornea. It was not because the Pentacam was a poor device, it was simply due the inherent limitations of trying to determine corneal power through elevation data analysis. Clearly if you cannot rely on a device for the anterior cornea then you are not likely to be able to rely on it for the posterior corneal data either. The axial resolution required to tell a difference of 0.25D is actually only one micron which is not possible with any device at present. For example, the brand new Zeiss Cirrus 6000 Spectral Domain OCT can only capture down to 5 microns of axial resolution. This limitation in being able to determine curvature with height data is actually why the Ziemer Galilei has a placid disc topographer combined with its dual Scheimpflug system.

What is different about the Cassini compared to other topographers?
The Cassini does not use Placido disc technology for its curvature data and it does not rely on Scheimpflug or OCT for its posterior cornea data. The Cassini instead uses 700 multicolored LEDs to reflect off of the anterior cornea and 7 infrared (soon to be increased to 35) lights off of the posterior cornea. This system works like a GPS system where data can be triangulated to create a detailed map of the cornea, this process is enhanced by the use of the 3 different colors in its LEDs. In a placido disc system, because it is not multicolored, the system can confuse adjacent lines as they could blend together and the system would not be able to tell the difference. Placido disc systems will also give information in promotional materials like they compare “18000 data points” however these are not truly separate data points as they all come from the same ring (hence most data points are related and not unique) and all they are really telling you is the resolution of the camera that captures the image of the rings. Placido disc systems typically do not also give you quality factors (certain high end models such as the Galilei do give some). The Cassini immediately tells your technician if the image is adequate by not only giving a green indicator if it is good but also a percentage value so they can help determine if images are getting better or worse with repeated capture. Cassini evaluates each capture for centration, focus, corneal coverage, stability, and amount of posterior data points captured. If any of these values are too low the technician knows to repeat it. In my practice my technicians output both a Diagnostic Report and a Color LED Grid Report on all patients (see below).

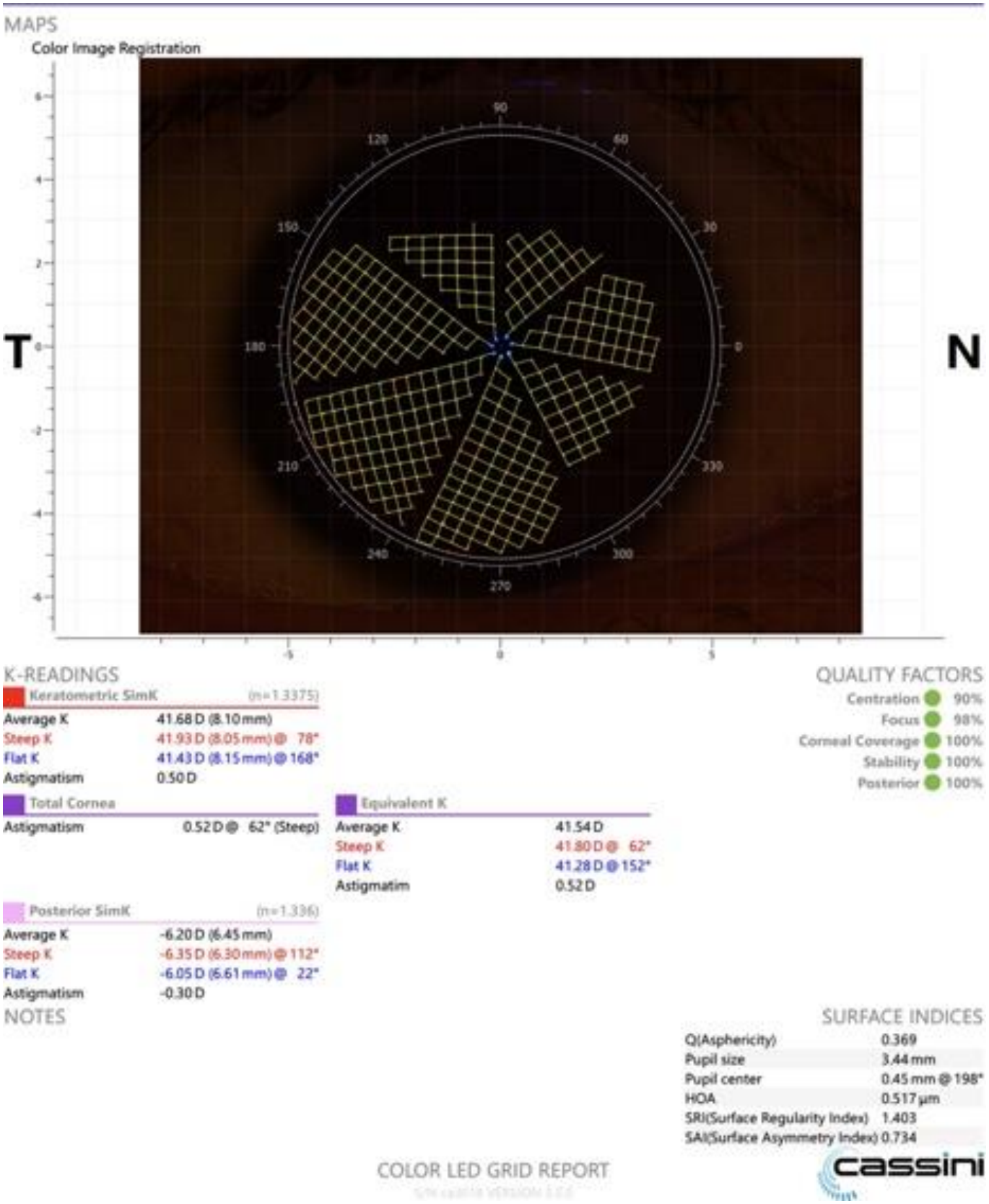
The diagnostic report (see below) gives me data on keratometry, posterior astigmatism, surface regularity, surface asymmetry, and higher order aberrations. The LED Grid Report shows me all of the lights that were captured connected by a honeycomb like grid so that I can see exactly what the data was based upon. This tool is also great for detecting issues like dry eye where many LEDs may not be well received by the sensor, alerting me to a problem.

The posterior LEDs are most people’s greatest interest in the Cassini system. The system works by reflecting 7 infrared LEDs off of the cornea. The system then sees the tiny dot of reflection from where each IR LED reflects off of the posterior cornea. This data is like getting posterior keratometry that can be combined with the highly detailed topography of the 700 multicolored LEDs that reflect off of the anterior cornea. Many people have discussed this with me and thought the 700 LEDs are

evaluated off of the posterior cornea but this is not how the system works. At present it is only 7 LEDs that are arranged in a ring. This would be similar to the 6 LED reflections that the original IOLmaster used to get anterior curvature data. But in this case it is getting posterior data. The newest Cassini 3.0 (Cassini Ambient) has increased the number of posterior lights to 35 but this feature is not activated as of August 2020.

Why is LED reflection better than Scheimpflug for posterior cornea data?
Cassini LED reflection is better for 2 reasons. First, the Scheimpflug systems are by nature relatively slow to capture and so small amounts of movement can occur from microsaccades. Small amounts of eye movement can affect the quality of the data. Both Scheimpflug systems on the market recognize this limitation and have developed different strategies to deal with it. The Pentacam spins around the eye twice and averages the data; however, this takes nearly 2 seconds which is plenty of time for significant eye movement. The Galilei system came out after the Pentacam and instead uses two cameras to capture the cornea from two opposing angles. The Galilei then averages the two images, which allows it to capture the data in a much quicker 0.75 seconds, but this is still is plenty of time for small amounts of eye movement. The Cassini on the other hand is just reflecting light so it takes no time at all, and is essentially an instantaneous capture.

The second advantage of the Cassini is due to the inherent advantage of measuring curvature by reflection (ie Keratometry) of light where we can detect differences of 0.01 D accurately. As we mentioned earlier measuring curvature by elevation data requires a level of resolution of 1 micron to be accurate to 0.25 D and current technology at best only allows 5 micron resolution. This means that if a topography system were to launch in the US that utilized high resolution OCT for posterior data (5 micron resolution) and placido disc for anterior data (none are currently available in the US as of August 2020) it would still be limited in its capabilities to fully address posterior corneal astigmatism.



Above is my Color LED Grid Report. You can see complete honey comb pattern over my cornea showing that the device was able to visualize my LED reflections. The

quality factors of centration, focus, corneal coverage, stability, and posterior are all in the green and approaching 100%.

What do I like most about the Cassini?

I do really enjoy having posterior corneal astigmatism data from the Cassini for toric IOLs but I actually find the device the most useful when planning premium Multifocal cases. The reason is that the topographic data from the Cassini is the most repeatable data I have seen from any device. This is important for getting sim K values but honestly I get adequate K values from the Lenstar and Galilei. The device really shines in its analysis of corneal higher order aberrations but more importantly being able to measure them accurately and repeatably. This fosters trust in the system especially combined with the previously mentioned quality indicators.

Corneal higher order aberrations are the most important value you can look at to determine if a patient will be a good candidate for a multifocal IOL. If your patient already has elevated HOA values from conditions that are easy to miss on examination such as ABMD or dry eye then they are likely to be unhappy with a multifocal IOL that is only going to further exacerbate the problem. The same is true for patients with prior refractive surgery. Some surgeons are occasionally shocked when they hear that I commonly put multifocal IOLs in patients with prior refractive surgery and rarely have any complaints. The reason is that not all prior refractive surgery is the same. If you place a multifocal IOL in a patient with a decentered ablation that is causing vertical and/or horizontal coma then this will become a problem with a multifocal IOL. The same is true for spherical aberration, trefoil, etc. The issue with higher order aberration analysis is that the values vary drastically from device to device and they must always be calculated at the same diameter. The generally accepted diameter is 6mm and this is the diameter that the Cassini uses to give its data analysis.

What values do I use as my cutoff of multifocal lenses when using the Cassini?

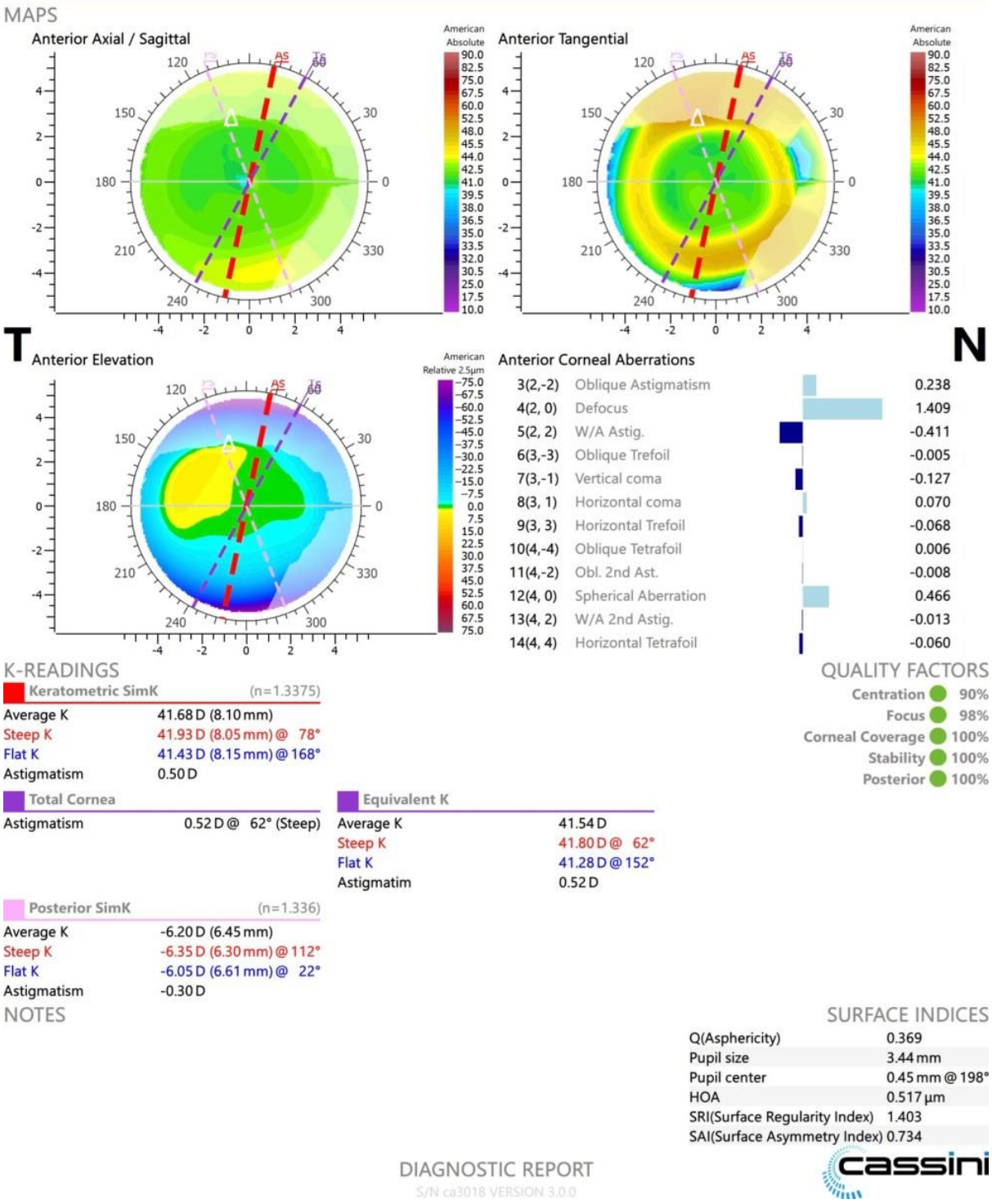
Higher Order aberration values are essential to look out on the Cassini printout. The Cassini will give you HOA data in two different forms. If you want to just take a quick glance at the total corneal aberrations you can look at the bottom of the Diagnostic report where it lists “HOA.” This value for most patients that have had no prior refractive surgery and have no corneal pathology will be in the range of 0.400 and 0.600. Values below this are totally fine and are sometimes seen in very young patients that I am screening for LASIK. Values above 0.600 require some further examination because elevations in these values can be seen with many cornea disorders including dry eye, ABMD, Salzmann’s nodules, Pellucid Marginal Degeneration, and Keratoconus or Forme Fruste Keratoconus. Whenever these values are elevated I always perform a careful slit lamp examination including instillation of light amounts of fluorescein with a fluorescein strip (Fluress is too thick and can mask subtle ABMD or dryness.)

In a patient who has had a relatively low LASIK correction for myopia you may see a value of up to 0.800 to 0.900. I find that HOA values up to about 0.900 a multifocal IOL is likely to be well tolerated. When the value goes over 1.00 I would be more hesitant. It is very common to see decentered ablations in cataract age patients because they had LASIK in the late 1990s where pupil tracking technology was often

non existent and treatments weren't well centered. This decentration leads to the HOA value called coma. If this value is over 0.400 that is often a redflag that you should avoid placing a multifocal IOL. This value can be horizontal or vertical coma as the decentration can be vertical, horizontal, or a combination of the two. All patients with prior LASIK I would highly recommend looking at the "Anterior Corneal Aberrations" bar graph to get these exact values.

LASIK, by its very nature, leads to the problem of spherical aberration. Our cornea naturally has positive spherical aberration and this is the reason that modern aspheric IOLs by Alcon and Johnson and Johnson have negative spherical aberration values of about 0.20 to offset this naturally occurring spherical aberration. Myopic LASIK increases this value so you may see values of 0.500 or more in patients with prior myopic LASIK. Hyperopic does the opposite; it lowers spherical aberration so these patients often have values close to zero or even negative spherical aberration. Due to this, some surgeons will put negative spherical aberration lenses (exaples are J&J ZCB00 and Alcon SN60WF) in patients with positive spherical aberration and aberration neutral lenses (example the Bausch and Lomb Envista) in people with negative spherical aberration. If this is your desire this is included on the anterior Aberration chart and the Cassini will help you in this endeavor.

What makes the HOA values of Cassini better than other technologies?
The HOA values are highly repeatable. Meaning that if you get a coma value of 0.560 on one scan then you will likely see that a similar value on a scan done 5 minutes or even 5 weeks later (assuming the aberration isn't due to dry eye.) I have not found this to be the case with other technologies. The same is true for values like spherical aberration. You will often find spherical aberration is so accurate that if you are having difficulty determining by history and topographic appearance if a person had prior hyperopic or myopic ablation, then you can determine by looking at the spherical aberration value. If they had myopic it will be higher and if they had hyperopic it will be close to zero or even negative. When you are looking for these higher order aberrations then you need something that is accurate and repeatable if you are going to make important decisions, such as when to place a multifocal IOL and when to avoid them.



Above is my Diagnostic report. I have had a low level of myopic PRK, approximately -3.00D. This can be seen with central flattening on the tangential scan, decreased K values or 41.68, and a slight increase in spherical aberration at 0.466, but an overall normal HOA value of 0.517. I would definitely implant a multifocal IOL in this eye if the scan was of my patient. The coma, trefoil, and tetrafoil values are all low. My surface regularity index is a bit elevated most likely due to some dryness. Surface aymmetry index is normal as the ablation is perfectly centered on my visual axis.

What are Surface Regularity Index (SRI) and Surface Asymmetry Index (SAI)?

SRI and SAI are values seen on some other topography devices but again these values are highly repeatable on the Cassini. Surface Regularity Index is a measure of how regular the surface is which means that an irregularly irregular surface like we see in dry eye or ABMD will have an elevated value. Normal values in my experience are typically 1.0 or less with Cassini and anything above 1.7 is definitely abnormal. Surface Asymmetry index is abnormal when the corneal surface is asymmetric. The classic examples of this include the diseases of Keratoconus, Pellucid Marginal Degeneration, Salzmann's nodules, and corneal scars. Similar to SRI, abnormal values are typically over 1.0 and values above 1.7 are definitely abnormal. These values are similar to HOA in that a quick glance at them can reveal an issue that could create a large issue postoperatively. If you miss a subtle Salzmann's nodule or map lines of ABMD causing irregular astigmatism this can create problems with toric and multifocal IOLs. I have received multiple referrals from doctors who have missed these findings and created large issues by placing toric or multiofocal lenses that were not appropriate. I suspect they would not have made this mistake had the Cassini been part of their preoperative armamentarium. Just this week I had a patient referred for cataract surgery who's real issue was a Salzmann's nodule that was so subtle I only picked it up after seeing a very irregular surface on her Cassini. Had I performed cataract surgery she would have likely seen minimal to no difference in visual quality but I instead scheduled her for a superficial keratectomy which will greatly improve her vision.

When is a Scheimpflug system better than the Cassini?

The Cassini does not get an image of the entire posterior cornea. It only has reflection data from 7 points at present and with the new Cassini 3.0, or Cassini Ambient, this number will increase by another 28 points to 35 once this feature is unlocked. This means that it can not give you localized elevation data like you would obtain from a Pentacam or Galilei. Hence if you are looking to screen for keratoconus by evaluating the posterior cornea like you would with scanning slit (ie Orbscan) or Scheimpflug (Pentacam and Galilei) that this is not possible with the Cassini. The Cassini also cannot give you a thickness map of the whole cornea like you would get with anterior segment OCT. Therefore, if you are performing LASER refractive surgery like PRK, LASIK, and SMILE and typically use this data to screen candidates you will need one of these other devices. As I perform LASIK, PRK, and SMILE I have the Zeiss Cirrus 6000 that I use for epithelial thickness analysis and a Galilei G4 that I use for posterior shape analysis. I do not routinely use the Galilei for cataract evaluation patients as the Cassini gives me more pertinent information in this patient population. However, I do use both the Cassini and the Galilei on LASIK evaluations as I find the repeatability and quality of the Cassini's anterior corneal LED reflection to be superior to the placido disc images from the Galilei.

Why does the Lenstar go so well with the Cassini?

The Haag Streit Lenstar utilizes dual zone keratometry with 32 closely spaced infrared LEDs to provide its keratometry values. This is a huge step up from the original IOLmaster and even the IOLMaster 500 that replaced it. Both of those devices used a single zone of 6 LEDS. This meant that anytime the patient's true axis of astigmatism was away from any of these 6 LEDs that the axis and power would be less accurate. I utilized the IOLmaster version 5.4 prior to upgrading to the Lenstar and immediately found a much better correlation of axis with topography as

the 32 LEDS allowed for much more accurate Ks. The K values of the Lenstar still wouldn't line up perfectly with my Nidek OPD placido disc topographer sim K values though. This changed when I switched to the Cassini where correlation is within a few degrees in nearly all cases.

When we added Cassini we would capture the Cassini, Nidek OPD, and Lenstar on all of our patients and found near perfect agreement with Lenstar and Cassini but less agreement with OPD. I have always found Placido disc technology (such as the OPD) to be less accurate for determining K values because it can be influenced by low quality ring data. The alignment of data between Lenstar and Cassini really gives me confidence when placing a toric IOL that I have the power and the axis obtained as accurately as possible. The Cassini then gives me the posterior data that I can compare to the Barrett and Abulafia-Koch toric calculators that are built into the Lenstar. If I see a big difference in predicted astigmatism (from Barrett) and measured (with Cassini) then I can recalculate the toric IOL with the Cassini data. We really have come a long way since my residency where we would use Auto Ks/ manual Ks and ultrasound axial lengths!

Where is Cassini topography technology going?
Cassini is moving toward easier scan acquisition (for patient and operator) and improved integration with femtosecond cataract technology. The original Cassini device had a few downsides that slowed its adoption. The most important one was the light intensity of the 700 LEDs was so intense that patients had difficulty keeping their eye open during acquisition. The company worked around this by allowing most of the alignment to be done using infrared illumination. Then the bright LEDs would only need to light up for a few seconds during image acquisition. However, some patients still found this illumination to be too much. Fortunately, in 2020 the Cassini 3.0, or Cassini Ambient as they are calling it now, was launched. The Cassini Ambient uses LEDS that are far less bright and easily tolerable by nearly all patients. It does this by taking advantage of a high-quality, low light camera to capture these less bright LEDs. Also, the Cassini ambient has added 28 more infrared lights to reflect off of the posterior cornea to allow a higher amount of data points for posterior keratometry data. My practice upgraded to the Cassini Ambient in January and my technicians and patients find it much easier to use compared to our original model.

Lastly, the Cassini has announced that it will integrate with the J&J Catalys femtosecond laser around Q4 of 2020. This will allow surgeons to have the Cassini autopopulate and calculate femtosecond LRIs, but more importantly the Cassini captures a detailed iris image that is then utilized to under the Catalys Laser to place the femtosecond arcs exactly where intended. Also, there is no need for any form of external marking on the day of surgery to help account for cyclotorsion. This will save a step but more importantly reduce the inaccuracy of large marks that can easily be off by several degrees.

https://www.jjvision.com/press-release/johnson-johnson-vision-announces-fda-clearance-catalys-cos-60-software-address-unmet

Conclusion

If I had a cataract only practice, I would purchase 2 devices, one would be a Lenstar or an IOLMaster 700, (as they both have increased LEDS for determining anterior corneal curvature) and the other would be a Cassini topographer. Cassini topography will serve you well for toric IOLs and for evaluating patients prior to placing a multifocal IOLs. With these two technologies you have access to time tested keratometry of the Lenstar or IOLmaster and reliable, repeatable, and quality checked topography of the Cassini. The latest Cassini 3.0 (or Cassini Ambient) is a significant upgrade over the original version and I would recommend purchasing this device new from the manufacturer unless you happen to find this latest version on the used market which would be unlikely at the present time (August 2020).

Dr. Swanic has no financial interest in any device discussed in this article. He is not a paid consultant or advisor for any of the discussed technologies.